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WAR MACHINE

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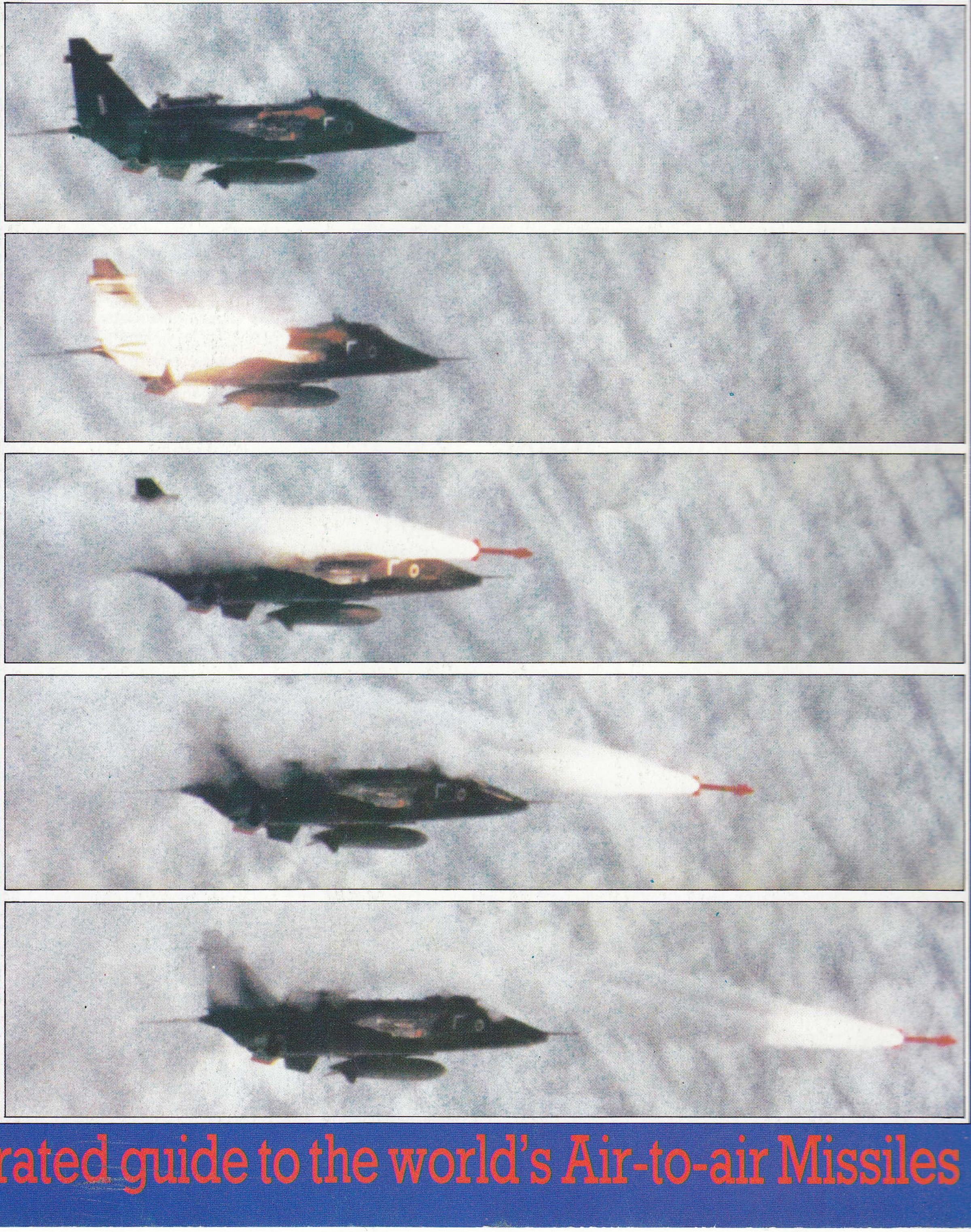

Armed Forces of the World: US Navy (Part 2)

Missile Guidance Systems

Sidewinder in Action

NATO's new generation of air-to-air missiles – AMRAAM and ASRAAM

A fully illustrated guide to the world's Air-to-air Missiles

WAR MACHINE

Volume 3 **Issue 35**

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Armed Forces of the World:

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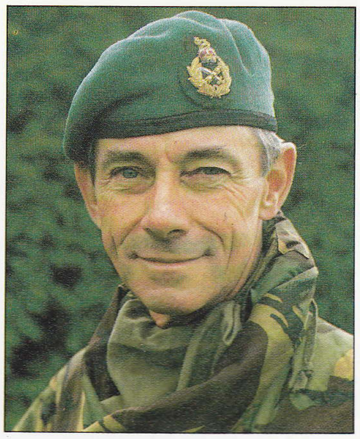

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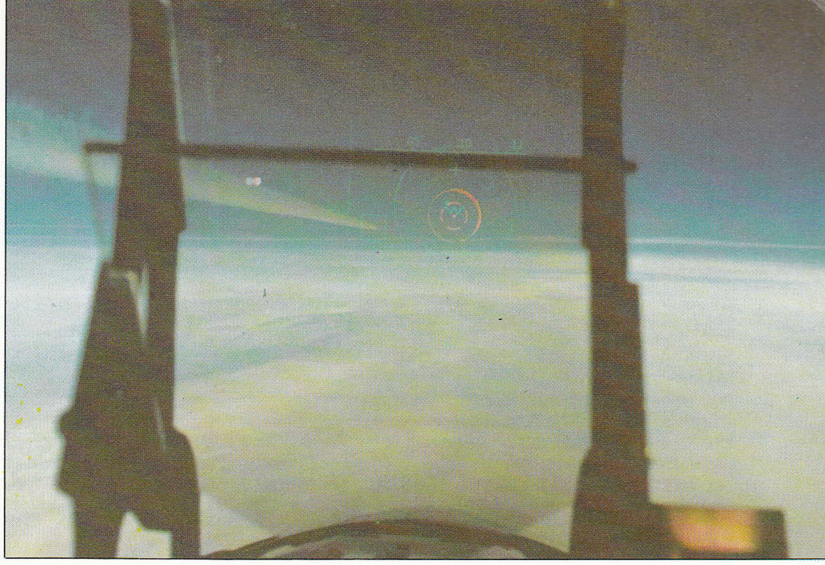
Air-to-air Missiles

The modern air-to-air missile has almost completely replaced the gun for interception and for close-in dogfighting. Even the smallest nations now arm their fighter aircraft with simple short-range missiles, often earlier-generation missiles without head-on capability or new-technology seekers.



An unusual 'pilot's-eye view' of an AIM-7F Sparrow streaking away from a McDonnell Douglas F-15 Eagle. The Sparrow's powerful rocket motor will accelerate the missile to around four times the speed of sound, and in action the enemy pilot might never see the weapon that kills him.

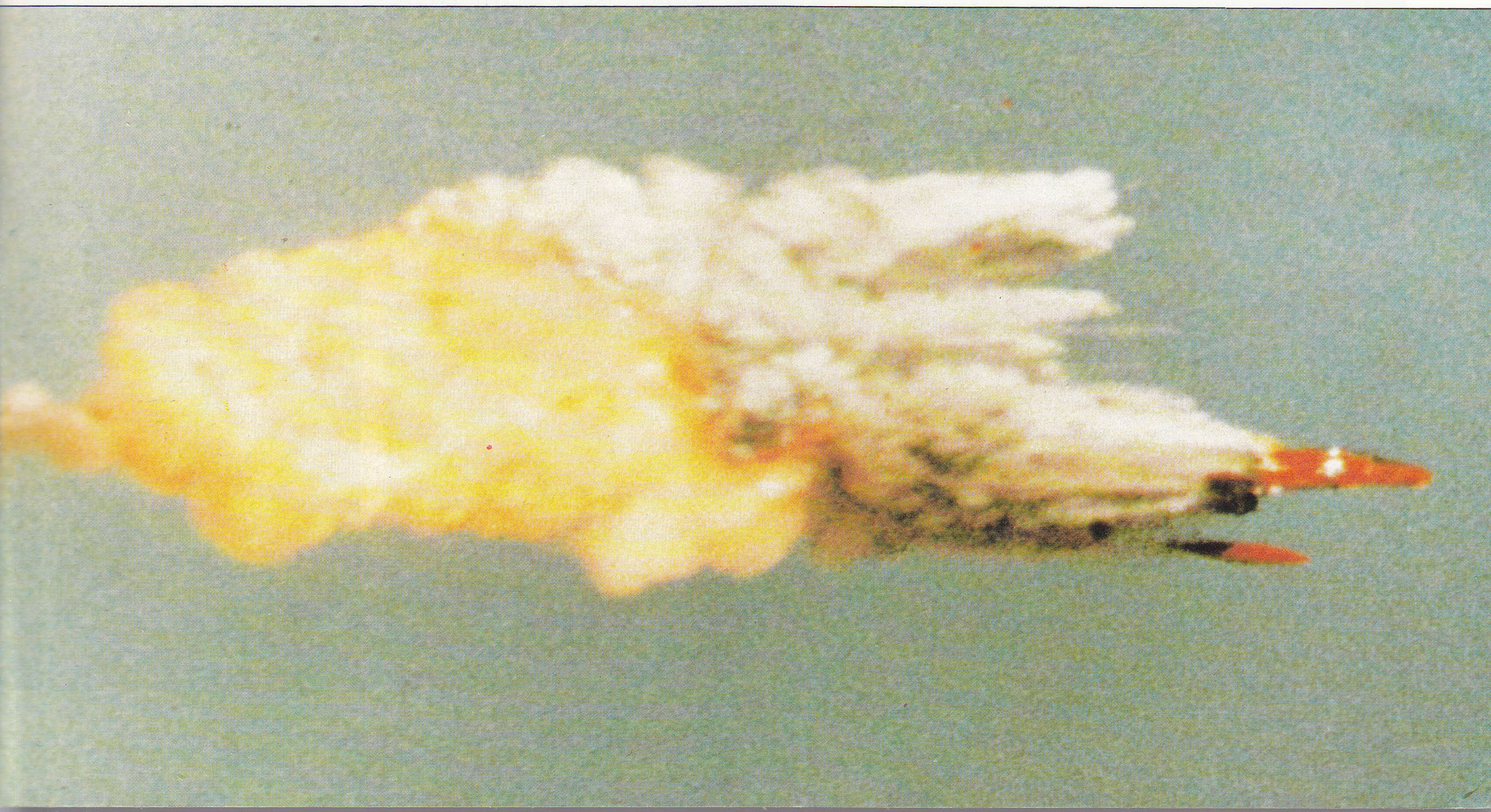
The story of the modern air-to-air missile (AAM) with its own onboard guidance unit started in the West in the late 1940s with systems that were developed specifically to destroy large bomber-size targets. By the late 1950s and early 1960s the missiles had evolved into two distinct classes: small short-range infra-red (IR) guided types for close-range air combat, and the large semi-active radar homing (SARH) types for long-range engagements. The Vietnam War produced single-shot kill probabilities of 0.09 for the SARH Sparrow and 0.18 for the IR Sidewinder missiles. This proved to the Americans that the tactical theory they had developed along with the missiles for air-to-air combat had vastly overestimated missile effectiveness, especially in the context of the low-level combats against small and nimble fighter-size targets. So the Americans (and therefore NATO) had both to rethink tactics and to develop new missiles or modify old ones to take account of the lessons learnt.

In the meantime Israel had gone her own way and produced very high kill ratios against the Arabs during the many air battles fought in the Middle East, progressively applying the lessons learnt to begin the development of her own IR-guided dogfight missile, the Shafrir, at the same time relegating the radar-guided missile to special engagements. By the 1982 Falklands war the UK had at least appeared to digest most of the lessons of the previous air wars, and in a moment of brilliant inspiration the Ministry of Defence ordered the part-equipment of the Royal Navy's BAe Sea Harriers (already on their way south) with the American AIM-9L Sidewinder IR-guided missile. These missiles, coupled with the excellent air combat training of the Fleet Air Arm pilots, ensured an incredibly high single-shot kill ratio against Argentine aircraft. The 1982 tally of aircraft lost to AAMs was increased to over 100 when the Israeli air force decimated the Syrian air force in a number of air battles over Lebanon during the invasion of the southern part of that country by Israel. Shafrirs, Sidewinders, the new Python and a limited number of Sparrows were used to inflict the majority of Arab air losses.

However, as the American systems are now getting long in the tooth, new systems for both short- and long-range engagements are under development with the designations ASRAAM and AMRAAM respectively.

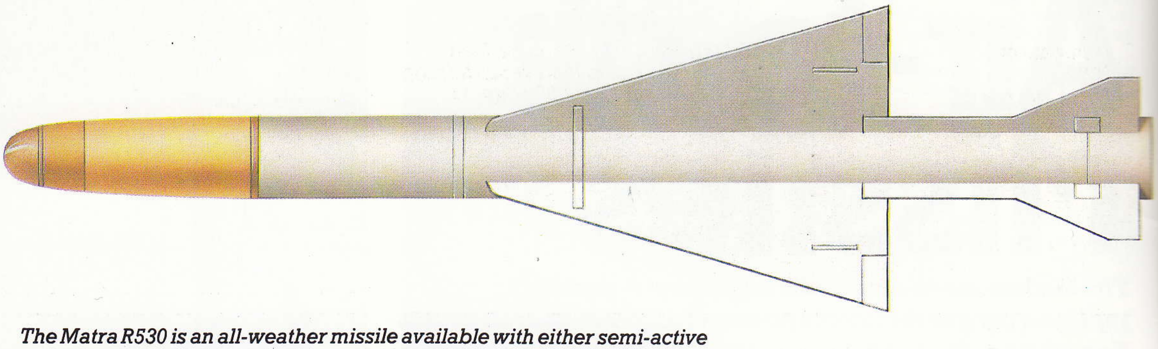
Meanwhile the Soviets had in their own inimitable manner gone their own way, following a logical development programme for each AAM type deployed and matching the type to individual aircraft models. Like the NATO allies the Soviets are also developing new systems and, it is believed, using Western technology from compromised missiles to do so. What is readily apparent, however, is that the qualitative advantage once enjoyed by the West has now gone.

The almost inevitable result of a direct hit by a modern air-to-air missile. Here a QF-4 Phantom unmanned target drone erupts in a ball of fire after being hit during a missile test. Even a near miss is enough to destroy an aircraft, as most modern missiles have proximity fuses.



FRANCE

Matra R530



The Matra R530 is an all-weather missile available with either semi-active radar homing or infra-red guidance heads. Although it is claimed to have all-aspect capability, it has not been outstandingly successful in combat, and is no longer in production.

Development of the **Matra R530** began in 1957, and the missile is still in service today after having been produced in both IR and semi-active radar homing (SARH) variants. The R530 is normally carried on Dassault-Breguet Mirage III and F.1 interceptors, although the French navy uses the type on its Vought F-8E(FN) Crusaders. Approximately 4,400 were produced, and the system has been sold to 14 countries. It has seen combat with the Argentine, Iraqi, Israeli and Pakistani air forces, but its success rate is not believed to have been high. In the IR type the homing contains the SAT Type AD3501 all-aspect (including head-on) seeker, whilst the alternate SARH version uses an EMD Type AD26 seeker guided by the Cyrano series radars of the Mirage family. A slightly different SARH seeker is used on the French navy missiles, which have to be compatible with the Crusader's radar. Normally one of each missile type is carried to improve the hit probability, although it is possible for the head to be exchanged at squadron level to meet the operational requirements. Propulsion is by either a Hotchkiss Brandt/SNPE Antoinette or a higher-performance SNPE Madelain dual-thrust solid-propellant rocket motor, and cruciform delta wings and tail fins are used for flight control. The R530 is currently used by Argentina, Australia, Brazil, Colombia, Egypt, France (air force and navy), Iraq, Jordan, Pakistan, South Africa, Spain, Venezuela and one other. Israel and Lebanon no longer operate the R530.

Specification

R530 (SARH)

Dimensions: length 3.284 m (10 ft 9.3 in); span 1.103 m (3 ft 7.4 in); body diameter 0.263 m (10.35 in)

Launch weight: 192 kg (423.3 lb)

Performance: speed Mach 2.7; range 18 km (11.2 miles)

Warhead: 27-kg (59.5-lb) continuous-rod or pre-fragmented HE with impact, delay and proximity fuses

Specification

R530 (IR)

Dimensions: length 3.198 m (10 ft 5.9 in); span 1.103 m (3 ft 7.4 in); body diameter 0.263 m (10.35 in)

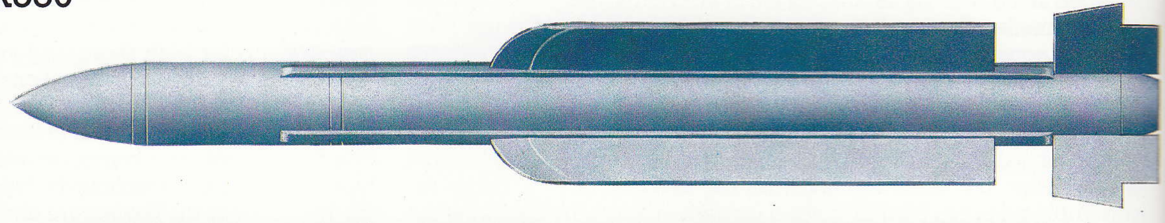
Launch weight: 193.5 kg (426.6 lb)

Performance: speed Mach 2.7; range 18 km (11.2 miles)

Warhead: 27-kg (59.5-lb) continuous-rod or pre-fragmented HE with impact, delay and proximity fuses

FRANCE

Matra Super R530



The Matra Super R530 is a developed version of the R530. It has increased range, speed and manoeuvrability compared with the earlier weapon. The Super R530 is already in service with French air force Mirage F.1 squadrons, and export orders have been received.

Essentially a development of the Matra R530, the **Matra Super R530** started life in 1971 to meet the higher speed- and altitude-performance requirements of the new generation of French interceptors. The **Super R530F** entered service in 1980 and uses an EMD Super AD26 semi-active radar homing head with Matra autopilot and proportional navigation system matched to the Cyrano IV radar of the Dassault-Breguet Mirage F.1. It can be used to engage targets either above or below the launch platform by vertical separations of up to 7000 m (22,965 ft) or 9000 m (29,530 ft) in the latest version. The latter is an improved model, the **Super R530D**, with a modified seeker head matched to the RDI/RDM radars carried by the Dassault-Breguet Mirage 2000 family. Service entry date for the Super R530D is expected to be 1986. To power the missiles Thomson-Brandt developed the Angèle rocket motor with a dual-composition solid propellant that has a much higher specific impulse capability than previous motors produced by the company. Flight control is exercised by four cruciform tail fins and four very low aspect body wings fitted midway along the missile's length. The missile body is constructed from steel and steel honeycomb and this, coupled with the use of a ceramic radome housing, allows the Super R530 to withstand speeds of up to Mach 4.6 and manoeuvres of up to 6 g at an altitude of 25000 m (82,020 ft); at altitudes up to 17000 m (55,775 ft) it can pull up to 20 g during an interception. At least 10 countries have now placed orders for the Super R530F, these being France, Kuwait, Libya, Morocco, Iraq and five unspecified countries.

A Matra Super R530 is fired from a French air force Mirage F.1. This combination seems likely to become a familiar sight, since most Mirage F.1 operators have ordered the Super R530 and the missile may already have seen action in the Gulf War, carried by Iraqi Mirages.

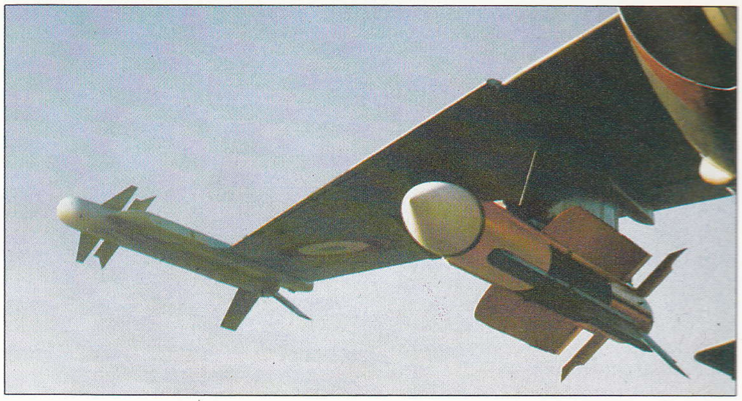
The Dassault Mirage 2000 will be the primary combat aircraft of the French air force from the mid 1980s. This development aircraft is carrying two Super R530 missiles inboard and two Matra R550 Magics outboard – a deadly combination.

Matra Super R530 (continued)

Specification

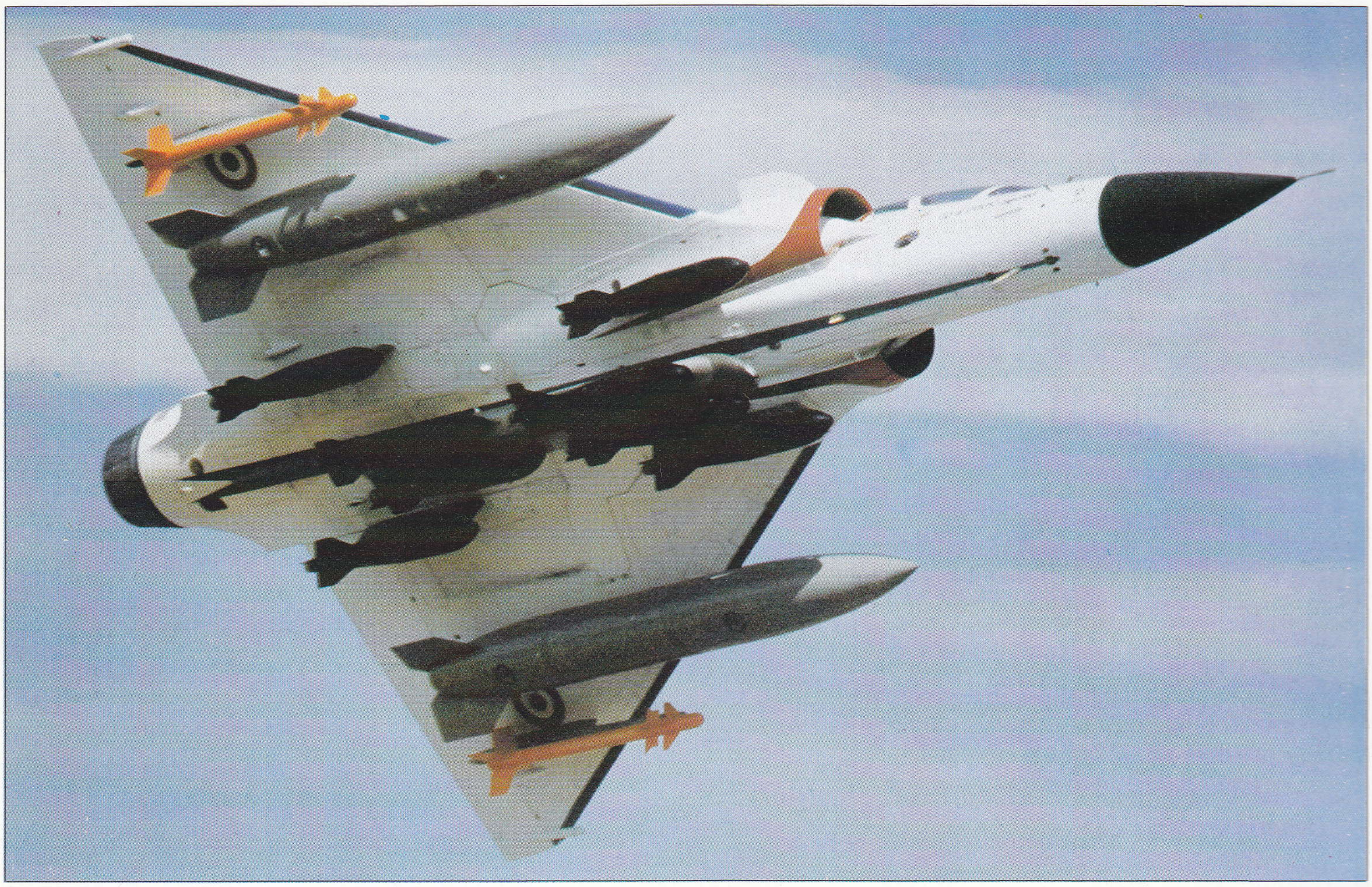
R530F
Dimensions: length 3.54 m (11 ft 7.4 in); span 0.9 m (2 ft 11.4 in); body diameter 0.263 m (10.35 in)
Launch weight: 250 kg (551 lb)
Performance: speed mach 4.6: range R530F 35 km (21.75 miles), and R530D 50-60 km (31-37.3 miles)
Warhead: HE fragmentation with radar proximity fuse and weighing more than 30 kg (66 lb)

A Matra Super R530 can be seen under the wing of this French Mirage F.1, while a Matra R550 Magic is carried on the wingtip launch rail. The Super R530 has been ordered by more than 10 nations.



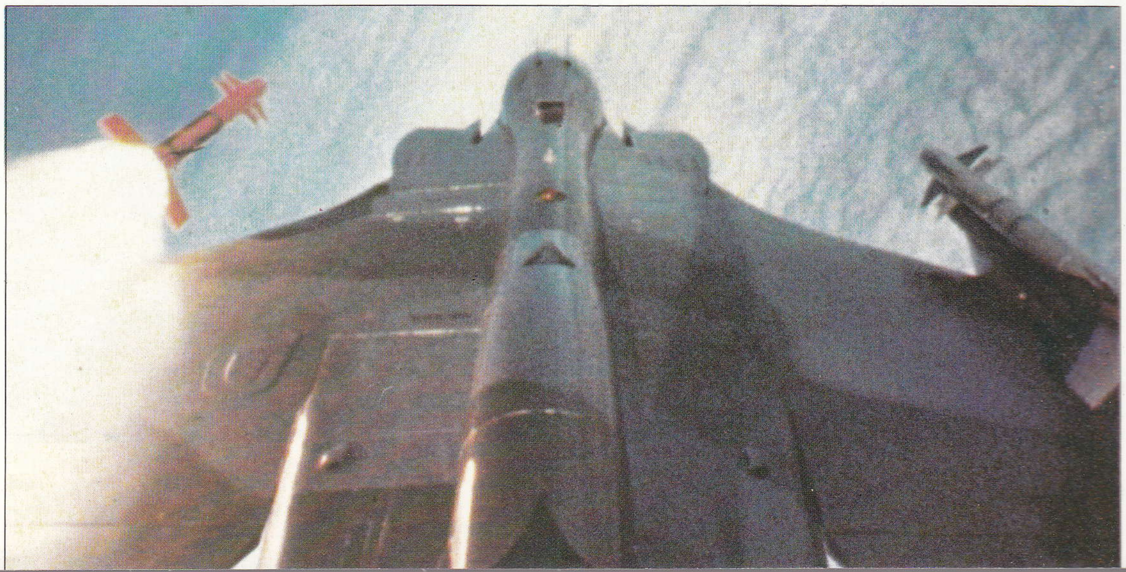
FRANCE

Matra R550 Magic

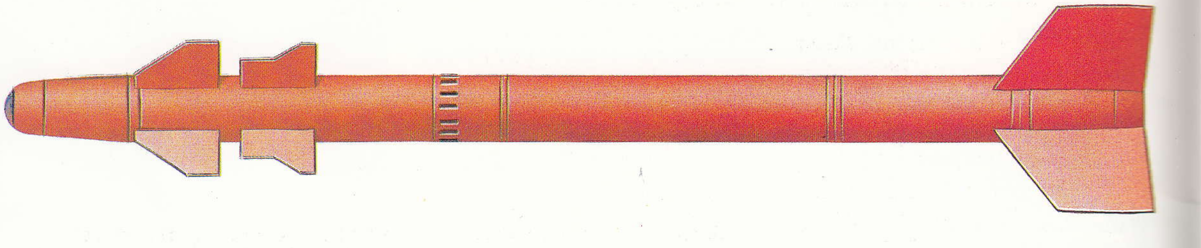


Above: A Dassault Mirage 2000 carries an impressive load of bombs and fuel tanks and a pair of Matra R550 Magic IR-homing air-to-air missiles. The Mirage 2000 will be the primary combat aircraft of the French air force from the mid 1980s.

Developed by Matra as a direct competitor to the US AIM-9 Sidewinder, the **Matra R550 Magic** began development as a company project in 1968, receiving official sanction via a French air ministry contract in the following year. The first fully guided round was launched on 11 January 1972 from a Gloster Meteor during a test launch against a CT-20 drone target. Further trials were then undertaken against manoeuvring targets until the missile was accepted into service in 1975. Since then both the French navy and air force have accepted the missile into their inventories, and more than 7,000 missiles have been ordered for them and by 18 other countries. The Magic has been cleared for use on the IAI Dagger, the Dassault-Breguet Mirage III, 5 and F.1, the Vought F-8 Cru-



The Magic is stressed for manoeuvres of up to 50 g, and can be launched from an aircraft in a 6 g turn. Although the Magic Mk I lacks head-on capability it is an effective and widely-used weapon.



The Matra R550 Magic is designed for 'close-combat' operations, and has been combat-proven in the Gulf War, carried by Iraqi Mirage F.1s and MiG-21s. The missile was used unsuccessfully by Argentina during the Falklands conflict.

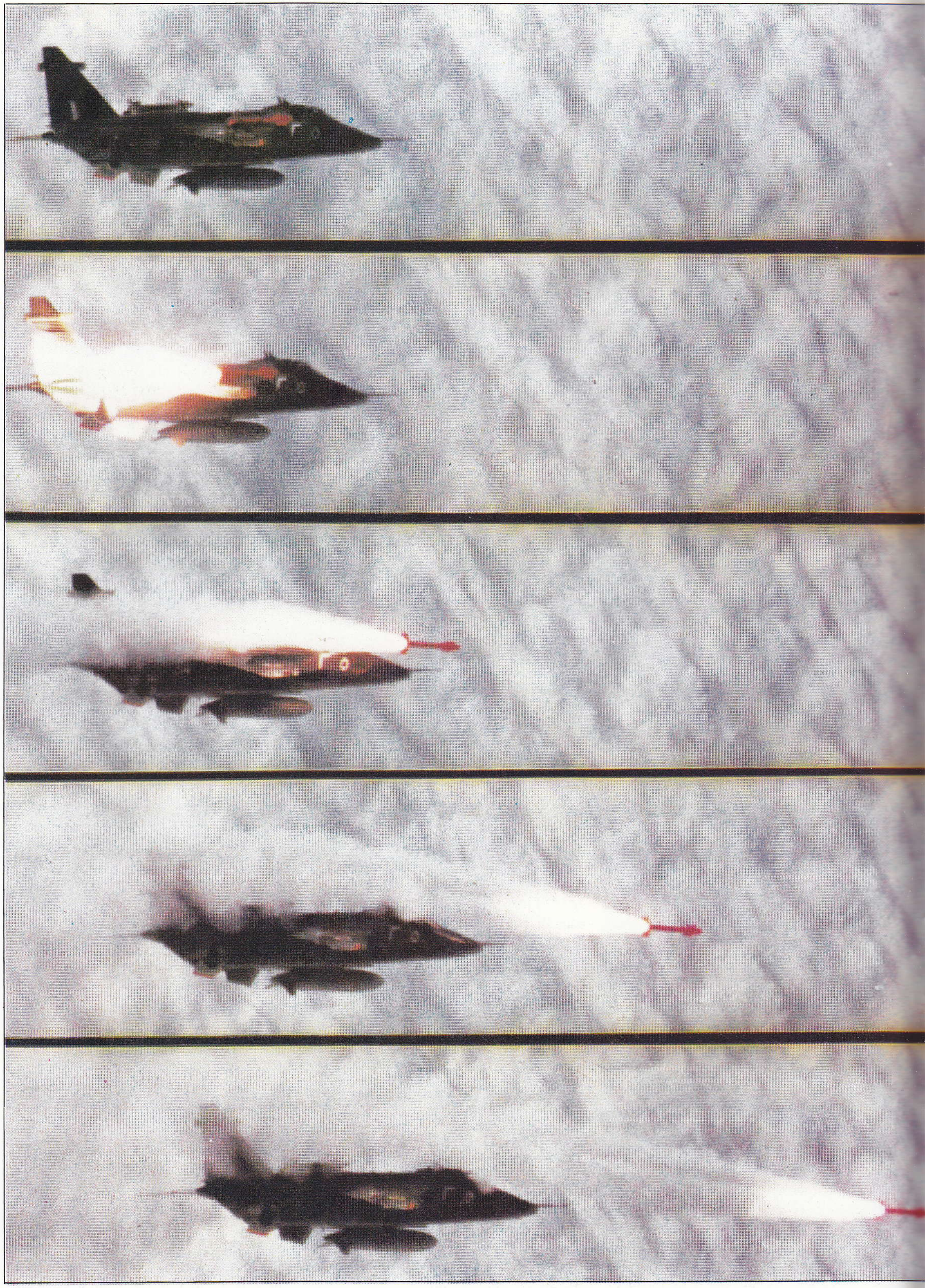
sader, the SEPECAT Jaguar, the BAe Sea Harrier, the Mikoyan-Gurevich MiG-21, the Dassault-Breguet Super Etendard, the Macchi M.B.326K, and the Dassault-Breguet/Dornier Alpha Jet.

In mid-1983 it was revealed that a **Magic Mk 2** was under development, with production to start in 1984. The Magic Mk 2 employs a new solid-propellant rocket motor, a new and improved IR homing head that includes head-on engagement capability with seeker slaving, and a new electro-magnetic proximity fuse.

The basic Magic Mk 1 can be launched from almost any target aspect (except head-on) within a 140° engagement envelope at all altitudes up to 18000 m (59055 ft). Above this height certain launch limitations apply. The missile can engage targets in a dogfight situation at around 300-m (985-ft) range and can be fired from an aircraft flying at over 1300 km/h (808 mph) and in 6-g manoeuvre. The IR guidance used is a SAT Type AD3601 homing head with a liquid nitrogen-cooled lead sulphide seeker element. Propulsion is by an SNPE Roméo single-stage composite double-base rocket motor, and cruciform canard fins are used for flight control. The Magic Mk 1 was used by Argentina in the Falklands war on her Mirage IIIEA interceptors without any success, but Iraq has scored a number of kills with it on her Mirage F.1E and MiG-21 fighters in the Gulf War against Iran. The Magic is currently used by Abu Dhabi, Argentina, Chile, Ecuador, Egypt, France (air force and navy), Greece, India (air force and navy), Iraq, Jordan, Kuwait, Libya, Morocco, Oman, Pakistan, Peru, Saudi Arabia, Spain and South Africa.

Specification

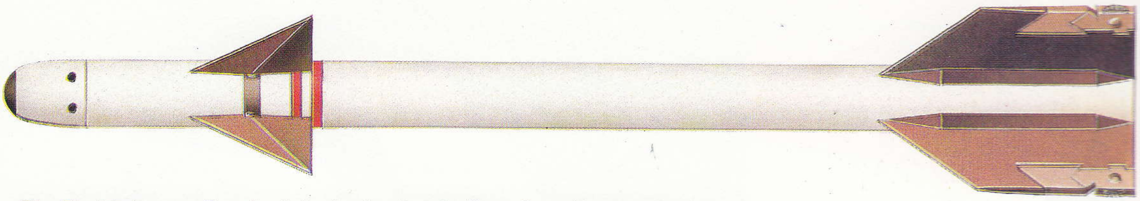
Magic Mk 1
Dimensions: length 2.75 m (9 ft 0.27 in); span 0.66 m (2 ft 2 in); body diameter 0.157 m (6.18 in)
Launch weight: 89.8 kg (198 lb)
Performance: speed Mach 3.0; range 0.32-10 km (0.2-6.25 miles)
Warhead: 12.5-kg (27.56-lb) conventional rod/fragmentation type, of which 6 kg (13.2 lb) is HE with delay action impact and passive IR proximity fuses



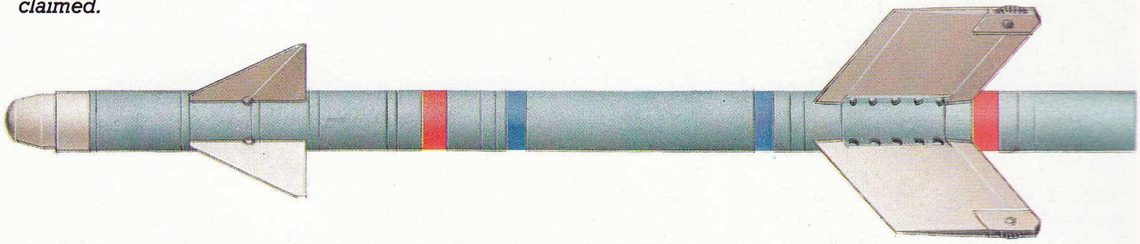
A Matra R550 Magic is launched from a development SEPECAT Jaguar International flying from BAe Warton and wearing RAF markings. RAF Jaguars seldom carry air-to-air missiles, but when they do they tend to carry AIM-9 Sidewinders. The Magic has been widely exported and is cleared for use on aircraft as diverse as the Sea Harrier and MiG-21.

ISRAEL

Rafael Shafrir and Python



The Shafrir is a small and relatively simple missile and requires no aircraft-installed equipment except the firing circuit. The missile has been extensively used in combat by the Israelis and a very high kill probability has been claimed.



The Python is a development of the Shafrir, with all-aspect capability and generally improved performance. Early versions of the Python are thought to have been used operationally over Lebanon.

Development of the **Raphael Shafrir Mk 1** infra-red homing missile began in 1961. By 1965 the Shafrir had surpassed its main rival, the AIM-9 Sidewinder, in most respects. This was due mainly to the greater body diameter, which allowed significant design improvements to be made to the internal installations that increased missile lethality. The Shafrir Mk 1 became the initial pre-production version, whilst the definitive operational model, the **Shafrir Mk 2**, entered squadron service in 1969. Since then the Shafrir has seen extensive use in combat against the Arab air forces and has been used on the Israeli air force Dassault-Breguet Mirage IIICJs, IAI Neshers and IAI Kfirs. To date it has destroyed over 200 aircraft and has a claimed single-shot kill probability of around 65-70 per cent. The Shafrir is a 'see-and-shoot' missile; when a target is detected within firing range, audio and visual signals alert the pilot, who then fires the round. Once this happens the IR guidance system takes over and the missile is then independent. During the 1982 Falklands war the Argentines used Shafrirs on their IAI Daggers in the initial air battles of 1 May, but hit nothing as the missiles were launched at long range and outside their engagement envelope. Other Shafrir operators are Chile, Colombia, South Africa, Taiwan, Turkey and three others.

In the same year the Israelis used against the Syrian air force what was thought to be a **Shafrir Mk 3** version in their invasion of Lebanon, but this subsequently turned out to be the development version of the **Python** air-to-air missile, which had first been revealed at the 1981 Paris air show. The Python has a more sophisticated and sensitive wider-look IR guidance seeker than the Shafrir, and is capable of being used from all engagement aspects (including head-on) at much longer ranges. Operational deployment of the definitive Python production version was expected in late 1983 or early 1984. Both missiles use moving canard surfaces for flight control purposes.

Specification

Shafrir Mk 2

Dimensions: length 2.47 m (8 ft 1.24 in); span 0.52 m (1 ft 8.47 in); body diameter 0.16 m (6.3 in)

Launch weight: 93 kg (205 lb)

Performance: speed Mach 2.5; range 0.5-5 km (0.31-3.1 miles)

Warhead: 11-kg (24.25-lb) pre-fragmented HE with contact, delay and proximity fuses

Specification

Python

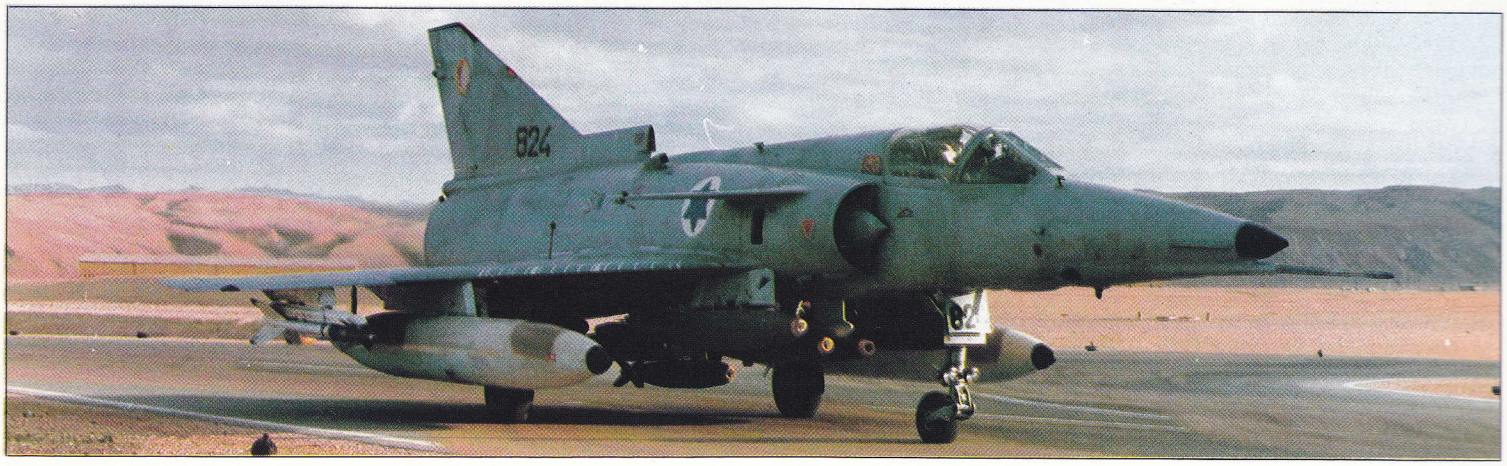
Dimensions: length about 3.0 m (9 ft 10.1 in); span not available; body diameter not available

Launch weight: 120 kg (264.6 lb)

Performance: speed Mach 3; range 0.5-15 km (0.31-9.3 miles)

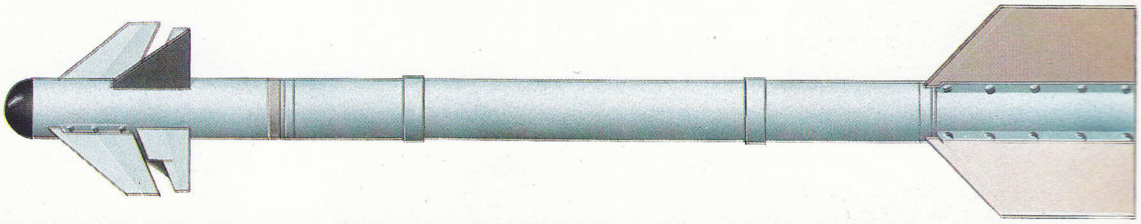
Warhead: improved version of type fitted on Shafrir

Shafrir production is augmented by use of AIM–9 Sidewinders, as seen on this Kfir. The Sidewinders are often modified to Shafrir standard.



SOUTH AFRICA

Armscor V3 and Kukri

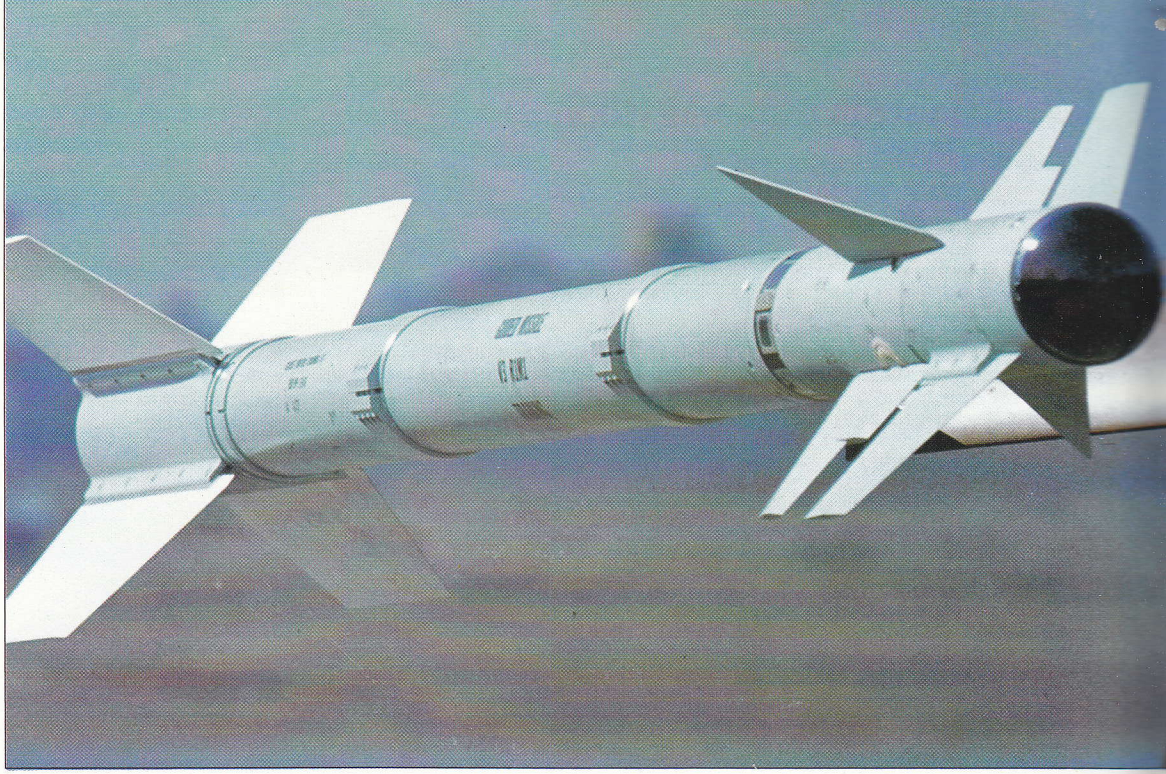


The Armscor V3 was the first air-to-air missile to be coupled to a helmet sight for target acquisition. Thought to be used only by the South African Air Force, the Armscor V3 may indicate the likely direction of future missile development.

Development of the **Armscor V3A** IR-guided dogfight missile was started in the latter part of 1971. The V3A was the first air-to-air missile to be coupled with a helmet-mounted sight, and entered production for the South African air force in 1975. In the same year research and development on an uprated **V3B** version started. This had an improved IR seeker unit with a larger target-acquisition angle, an upgraded rocket motor, and an increased helmet sight target-designation angle. The V3B entered production in 1979, and in 1982 an export version known as the **V3 Kukri** was cleared for sale to selected customers. All three versions use horizontal tandem canard control surfaces and single delta canards in the vertical plane for flight control. They have been cleared for use on the Dassault-Breguet Mirage III and F.1 aircraft and are known to have been tested on other types.

The helmet sight used is coupled to the missile seeker, and all the pilot has to do is look at the target; target acquisition is signalled to him by an audio tone in his headset, and he then designates the target to the missile via a switch on his control stick. This puts the missile into its tracking mode and once this happens the pilot can again move his head at will. Missile launch follows, although launch can also be performed in a dogfight during the aiming sequence provided that the audio tone is present. As far as is known no export sales of the Kukri have been made.

Specification
V3 series
Dimensions: length 2.944 m (9 ft 8 in); span 0.53 m (1 ft 8.86 in); body diameter 0.127 m (5 in)
Launch weight: 73.4 kg (161.8 lb)
Performance: speed Mach 3.0; range at low level 0.3-2 km (0.186-1.24 miles) and at high level 0.3-5 km (0.186-3.1 miles)
Warhead: HE fragmentation with delay action, impact and proximity fuses, and weighing more than 10 kg (22.05 lb)



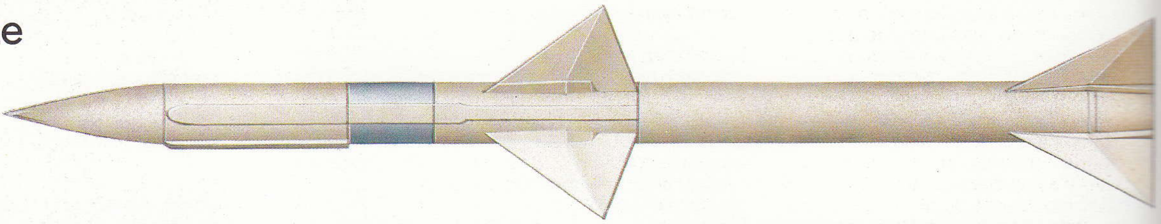
The Armscor V3's unique aiming and acquisition system, coupled with its incredible manoeuvrability, makes it an extremely potent dogfighting weapon. It can be fired over the entire flight envelope of the Mirage III and F.1 aircraft that carry it.

ITALY

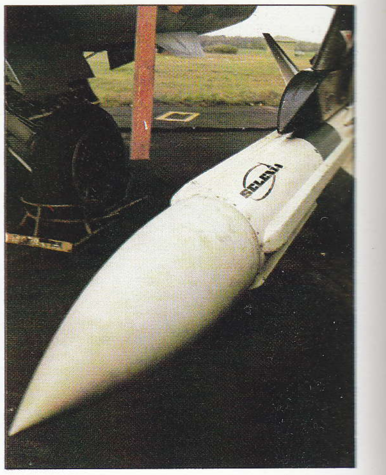
Selenia Aspide

Designed and built in Italy, the Selenia Aspide is a multi-role missile suitable for the air-to-air, land-to-air and ship-to-air missions. Development started in late 1969 and finished in 1977, when the first production rounds for the shipboard application were delivered. The missile is compatible with systems that use the AIM-7 Sparrow, and is similar in basic configuration to that missile. However, the Aspide has an advanced single-stage rocket motor that gives a higher thrust at burn out, and has a new guidance system that, when matched with an I-band monopulse fighter radar, gives the missile a significantly improved performance at very low altitudes, a better snapdown launch capability, and much better ECCM ability. The air-to-air version is used only by the Italian air force and since 1978, when the first production rounds of this variant were delivered, has gradually replaced the Sparrow on the Aeritalia F-104S Starfighter interceptor. The Aspide may also arm the Panavia Tornado at a later date. In comparison with the Sparrow, the Aspide has a redesigned radome and missile forebody and the moving control wings have new extended tips to give a greater span. The warhead is located forward of the wings and is of local design.

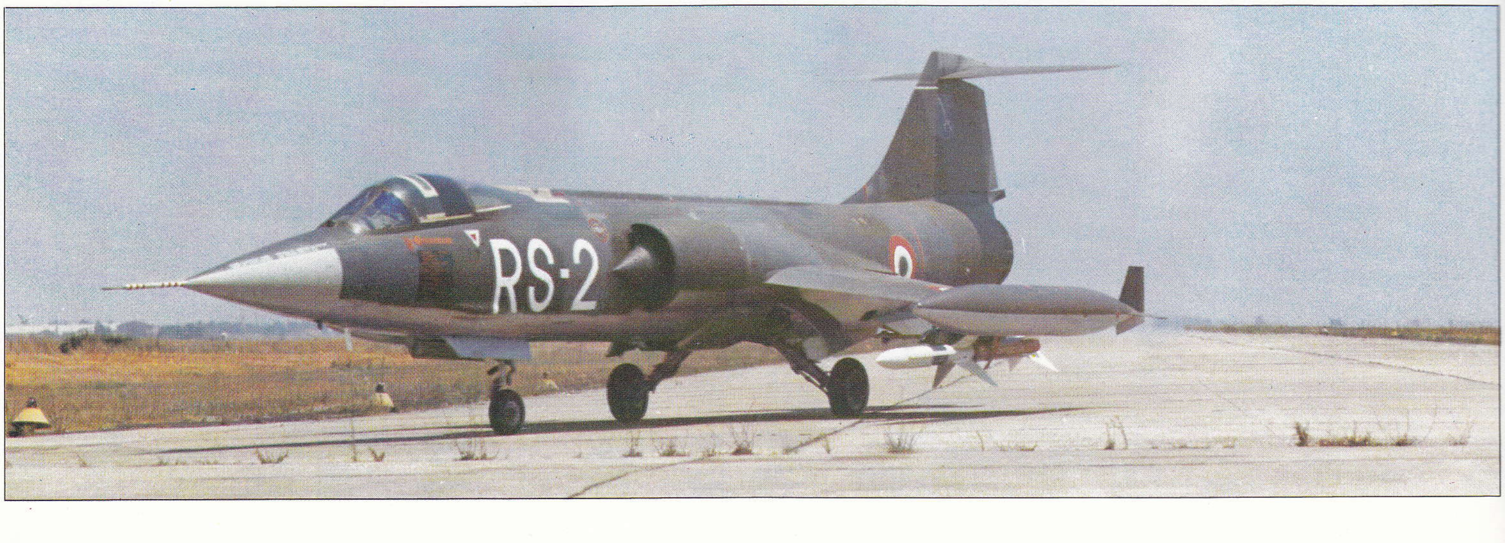
Specification
Aspide
Dimensions: length 3.70 m (12 ft 1.66 in); span 1.00 m (3 ft 3.37 in); body diameter 0.203 m (8 in)
Launch weight: 220 kg (485 lb)
Performance: speed Mach 4.0; range 44-70 km (27.3-43.5 miles) depending upon launch platform's speed and altitude
Warhead: 33-kg (72.75-lb) HE fragmentation with impact, delay action and proximity fuses



The Selenia Aspide is similar in configuration to the American AIM-7 Sparrow, but has a higher thrust rocket motor and a dramatically improved guidance system. It is also more effective at low level.



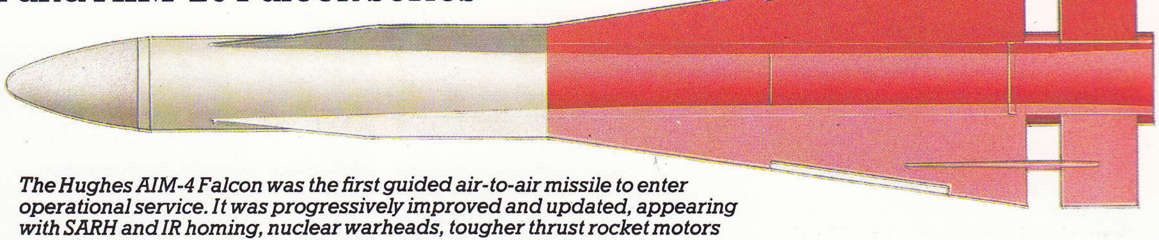
Right: The Selenia Aspide is a high-performance, all-aspect, all-weather missile which uses semi-active homing. When matched with the Starfighter's monopulse radar it has good ECM capability and a better snapdown launch capability.



Below: The Aspide is used only by the Italian air force on its Aeritalia F-104S Starfighter interceptors. It seems likely to arm the Tornado when this enters service in large numbers. Aspide is also available as a land-based surface-to-air missile.

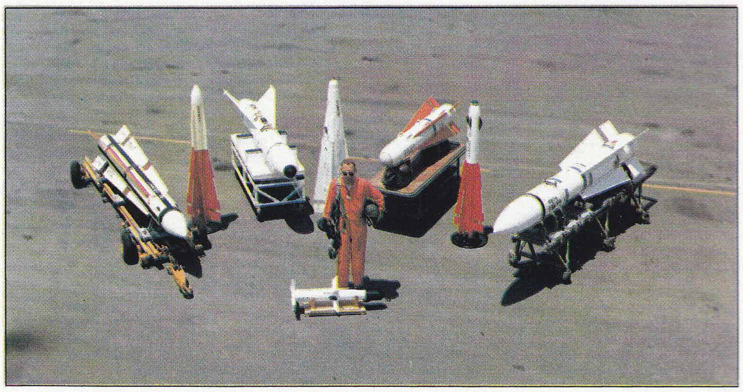
USA

Hughes AIM-4 and AIM-26 Falcon series



The Hughes AIM-4 Falcon was the first guided air-to-air missile to enter operational service. It was progressively improved and updated, appearing with SARH and IR homing, nuclear warheads, tougher thrust rocket motors and improved aerodynamics. The Falcon is to be retired shortly.

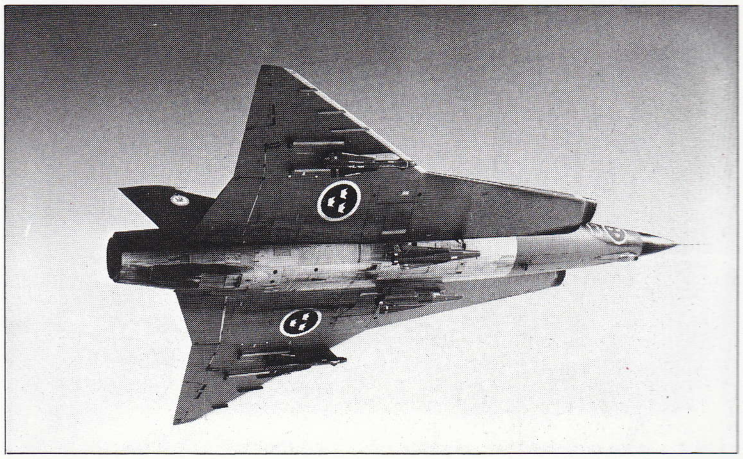
The **Hughes GAR-1 Falcon** became in the mid-1950s the world's first guided air-to-air missile to enter operational service with any air force, It evolved from a 1947 US Air Force requirement for a radar-based interceptor fire-control system and a guided missile for anti-bomber use by follow-on fighters. The latter entered production in 1954 and was redesignated **AIM-4** during the 1962 US armed forces redesignation programme. Over subsequent years the Falcon was progresively improved and built in both IR and SARH versions. It saw service during the Vietnam War on USAF McDonnell Douglas F-4D Phantom in its **AIM-4D** IR dogfight version, shooting down four Mikoyan-Gurevich MiG-17s and one MiG-21. The AIM-4D is still in service with some USAF and Air National Guard Phantom units together with a later variant, the **AIM-26B Super Falcon**, on the latter's Convair F-106 Delta Darts. The standard technique for aircraft equipped with a mixture of Falcon types was to fire one of each to improve hit probability, a tactic that was copied by the Soviet air force for most of its missile systems. All US Falcons are expected to be retired by the end of the 1980s, although some foreign operators may keep them longer. The AIM-4 and AIM-26 were both released for export, Sweden building both types under licence for its Saab 35 Draken interceptors; Switzerland also bought the missile for its small Dassault-Breguet Mirage IIIS force. The **AIM-26A** nuclear-armed 8.05-km (5-mile) range version of the Super Falcon with a 1.5-kiloton W-25 warhead was available as a guided alternative to the similar-yield 8.05-km (5-mile) range unguided AIR-2A Genie rocket. This was used for a number of years by the US Air Defense Command on its McDonnell Douglas F-101 and Convair F-106 interceptors. Apart from the USA, operators of the Falcon are Canada, Finland (from Sweden), Greece, Japan, Sweden (**Rb28** and **Rb27** licence versions), Switzerland (**HM55** and **HM58**), Taiwan and Turkey.



Right: This photograph shows the size of the Falcon (standing vertically) compared to the Phoenix (right).

Specification
AIM-4C (HM58 and Rb28) and AIM-4D
Dimensions: length 2.02 m (6 ft 7.53 in); span 0.508 m (1 ft 8 in); body diameter 0.163 m (6.42 in)
Launch weight: 61 kg (134.5 lb)
Performance: speed AIM-4C Mach 3.0 and AIM-4D Mach 4.0; range 9.7 km (6 miles)
Warhead: 13-kg (28.65-lb) HE with proximity fuse

Specification
AIM-26B (HM55 and Rb27)
Dimensions: length 2.07 m (6 ft 9.5 in); span 0.62 m (2 ft 0.4 in); body diameter 0.29 m (11.4 in)
Launch weight: 119 kg (262.3 lb)
Performance: speed Mach 2.0; range 9.7 km (6 miles)
Warhead: 18-kg (39.7-lb) HE with proximity fuse



Swedish-built Falcons (designated RB28) are carried under the wings of a Saab J35 Draken interceptor. The aircraft also carries two Swedish-built Super Falcons (known to the Swedes as the RB27) under its fuselage.

USA

AIM-9 Sidewinder series

Originally developed by the US Naval Weapons Center, China Lake, in the late 1940s, the **AIM-9 Sidewinder** is still in production in 1984 as a viable short-range air-to-air missile. The first IR-guided round was launched on 11 September 1953, production rounds entering US service in May 1956. The original versions were restricted in use to close-range rear attacks at medium to high altitudes in good visibility with a claimed 70 per cent single-shot shot kill probability. The early Sidewinders proved this claim in action only two years later, when in October 1958 the Chinese Nationalist air force fired a number of rounds from North American F-86 Sabres against Communist Chinese Mikoyan-Gurevich MiG-15s and MiG-17s during the brief conflict over the islands of Quemoy and Matsu. By 1962 the first major production variant, the **AIM-9B Sidewinder**, was in widespread service with NATO air forces, and further improvements were planned. The US Navy for a number of years used the solitary SARH variant, the **AIM-9C**, on its Vought F-8 Crusaders coupled to the fighter's APQ-94 series radar. A follow-on IR guided version, the **AIM-9D**, proved so successful in US Navy service that it formed the starting point for most of the subsequent modifications to give both air- and land-launched variants. New solid-state electronics coupled with expanded seeker head acquisition capabilities allowed large numbers of the earlier versions to be remanufactured as missiles with vastly improved performances, whilst entirely new versions were also developed. For instance, the **AIM-9L** that entered production in 1977 adopted an entirely new all-aspects IR seeker together with an improved warhead, fuse and rocket motor. Each new version incorporates technology that has been learnt from the lessons gained in combat use with Iran, Israel, Pakistan, the USA, Taiwan and the United Kingdom. It was the AIM-9L on Royal Navy British Aerospace Sea Harriers during the Falklands war of 1982 that allowed these aircraft to destroy 19 confirmed Argentine aircraft. All versions produced use cruciform canard fins for flight control and have solid-propellant rocket motors.

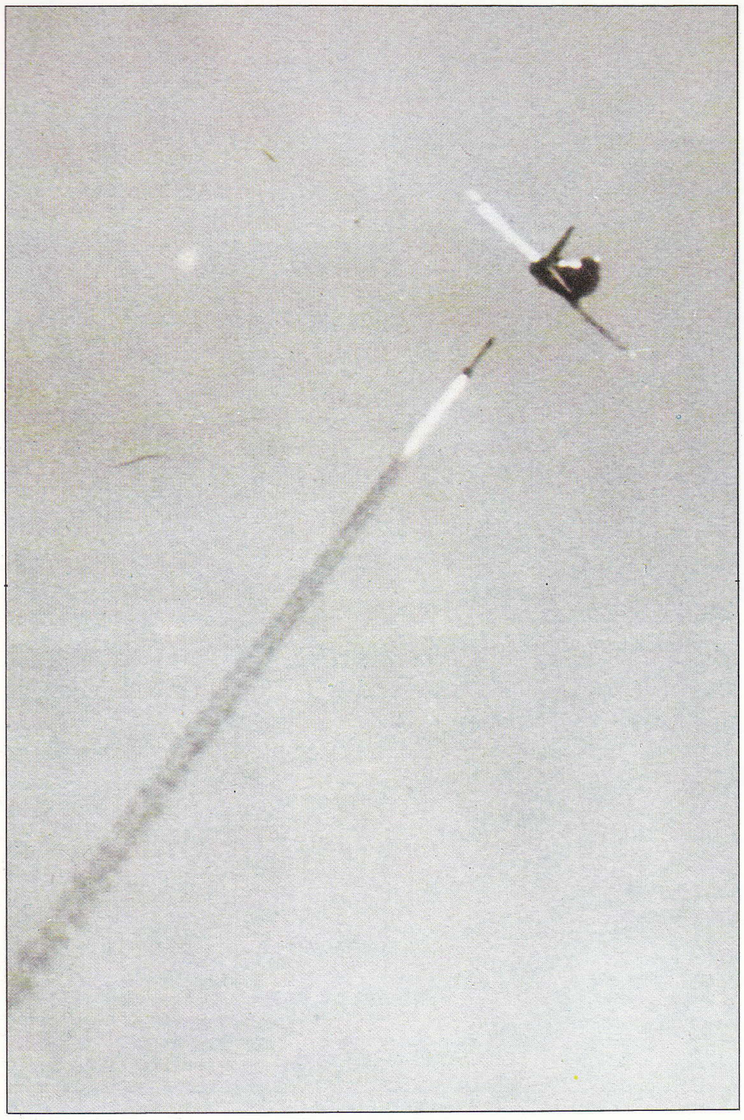
Currently about to enter service is the **AIM-9M**, a companion to the AIM-9L with the same dimensions and performance, but weighing in at 86 kg (189.6 lb) thanks to the use of an improved seeker with better IR counter-countermeasures and lock-on capability against strong IR backgrounds. Other modern Sidewinders are rebuilt older models, the **AIM-9N** being the AIM-9B/E upgraded to AIM-9J standard, and the **AIM-9P** comprising AIM-9B/E/J and new-build missiles to the approximate standard of the AIM-9J/L series with smokeless propellant.

Operators of the Sidewinder series are Argentina, Australia, Belgium, Brazil, Canada, Chile, Denmark, Egypt, France, Greece, Indonesia, Iran, Israel, Italy, Japan, Jordan, Kenya, Kuwait, Malaysia, Mexico, Morocco, Netherlands, North Yemen, Norway, Pakistan, Philippines, Portugal, Saudi Arabia, Singapore, South Korea, Spain, Sudan, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Turkey, UK (air force and navy), USA (air force, navy and marines), Vietnam and West Germany.

Specification
AIM-9B
Dimensions: length 2.83 m (9 ft 3.4 in); span 0.559 m (1 ft 10 in); body diameter 0.127 m (5 in)
Launch weight: 70.4 kg (155.2 lb)
Performance: speed Mach 2.5; range 3.2 km (2 miles)
Warhead: 4.54-kg (10-lb) HE fragmentation with passive IR fuse

Specification
AIM-9J
Dimensions: length 3.07 m (10 ft 0.87 in); span 0.559 m (1 ft 10 in); body diameter 0.127 m (5 in)
Launch weight: 78 kg (172 lb)
Performance: speed Mach 2.5; range 14.5 km (9 miles)
Warhead: 10.2-kg (22.5-lb) HE fragmentation with passive IR or active radar fuse

Specification
AIM-9L
Dimensions: length 2.85 m (9 ft 4.2 in); span 0.63 m (2 ft 0.8 in); body diameter 0.127 m (5 in)
Launch weight: 85.3 kg (188 lb)
Performance: speed Mach 2.5; range 17.7 km (11 miles)
Warhead: 10.2-kg (22.5-lb) HE fragmentation with passive IR or active radar fuse



A Sidewinder missile is typically fired from under two miles' range, its infra-red seeker homing onto the target aircraft's hot jetpipe.

New-generation Sidewinders, such as the AIM-9L, have an annular blast fragmentation warhead with a proximity fuse, giving greater lethality.

Sidewinder in Action

The AIM-9 Sidewinder has been in constant production since 1954 and has been used in virtually every air war since that time. Well over 100,000 Sidewinders of all marks have been produced, and the latest variants have all-aspect capability, higher manoeuvrability, more powerful warheads and more sensitive seekers.

No weapon system has ever been more cost-effective than the Sidewinder. The weapon was developed in 1950-4 by a small team at the US Naval Ordnance Test Station, China Lake, California, for less than one-thousandth of the annual cost of developing its modern equivalent. No fewer than 80,900 were made of the first production version, the AIM-9B, and for the past 30 years progressively improved Sidewinders have been virtually the standard close-range AAMs (air-to-air missiles) of the non-Communist world, and the commonest Communist weapon is a direct copy!

The Sidewinder is basically just a metal tube, of 127-mm (5-in) diameter, most of which is filled by a rocket motor which blasts it rapidly to about Mach 2.5. The tube also contains a warhead (which varies with the model of missile) and is stabilized by four tailfins each fitted with a small slipstream-driven flywheel at the tip to give a gyro effect. The vital guidance function is provided by the nose section, typically about 0.75 m (30 in) long. Right in front is a gyro-stabilized telescope which picks up heat (IR, infra-red) from a target and concentrates it on a sensitive cell. This converts the heat into an electric current which controls four pivoted fins around the guidance/control section. These fins steer the missile always towards the source of the heat. The shape of the nose and of the fins is totally different in different versions of Sidewinder.

The original AIM-9B had a hemispherical transparent nose and acutely swept delta fins. It had to be fired from astern of its targets. At first Sidewinders tended to home on to any source of heat available, including the sun, or sunlight reflected in a lake or a friendly greenhouse. Gradually the problems were solved, and IOC (initial operational capability) was reached in May 1956. No guided AAM has ever been easier to instal in a fighter, because the Sidewinder has never needed airborne radar (except in the rare AIM-9C version) and requires only simple avionics and wiring to the launch pylons. Thus it was soon carried by the McDonnell F2H-3 and -4, Grumman F9F-8, North American FJ-3 and -4, Douglas F4D and Vought F8U, as well as the McDonnell F3H-2

The missile can be seen to have blown off the entire rear fuselage of the North American QF-86 target drone.

The Grumman F-14 Tomcat that fired the missile flies through the pall of smoke left by its victim.

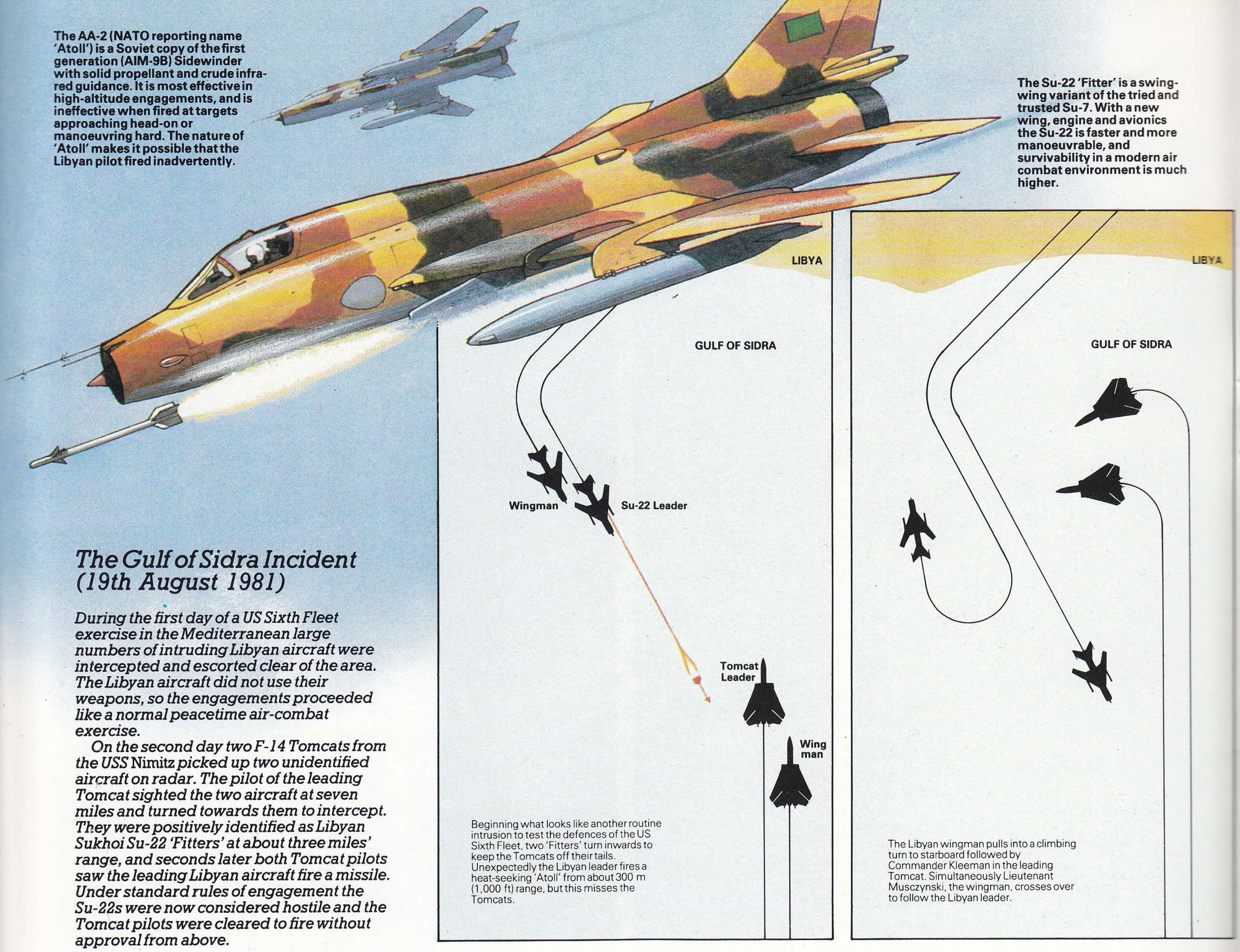
which in some models also carried the big Sparrow AAM. Both types of AAM came near to being fired in anger in 1958 when the US Navy and US Marines flew combat missions during a crisis in Lebanon.

At almost the same time friction between the Chinese and the so-called Nationalist Chinese in Taiwan came to a head when the Nationalist-held islands of Quemoy and Matsu were blockaded. Very soon the open warfare spread to the sky, and it so happened that Nationalist North American F-86F Sabres had lately been armed with Sidewinders, at that time known as GAR-8s by the USAF which supplied them. Only a few weeks earlier the Chinese pilots had gone through a crash course learning how to set the IR homing head of the selected missile on its target, causing a soft growling sound to appear in the pilot's headset. As the range closed, and the heat source grew apparently stronger, the growling strengthened and rose in pitch until it was a strident singing note. Then was the time to fire the missile.

Air combats had begun in August 1958, but it was 11 September before the first Sidewinder-armed F-86 got into action. The new AAM gradually became dominant, despite its still often unexplained propensity for failing to achieve lock on the right target. On 24 September 1958 the Nationalists claimed 10 Chinese MiGs, all downed by Sidewinders, without loss. This virtually stopped the onslaught from the mainland, 24 Chinese fighters having been shot down in 40 days. The only Nationalist losses were two Republic F-84G attack aircraft shot down during bombing runs. But a more important outcome was that the warhead of one Sidewinder failed to detonate, and it was carried back to China stuck in the jetpipe of the MiG-15 which it hit. Within two weeks it was in the Soviet Union and work was well advanced on the 'Chinese copy' later known as the AA-2 'Atoll', but actually designated K-13A, which was made in numbers even greater than those of the Sidewinder itself.

Of course, thousands of Sidewinders were carried by aircraft of the USAF, US Navy and US Marines during the Vietnam War, but probably the next place after China to see Sidewinders in action was Kashmir, over which large numbers of Indian and Pakistani fighter fought from August 1965. Outnumbered heavily, the Pakistani F-86F Sabres mostly had nothing but 12.7-mm (0.5-in) machine-guns, but 22 of them were wired up for Sidewinders. As the Indian Hawker Hunters, Dassault Mystères, Folland Gnats and MiG-21s did not know whether an opposing F-86 was armed with Sidewinders or not they tended to assume the worst, and the missile's effective range of 3.2 km (2 miles) was enough to deter Indian fighters from breaking off and trying to run for home. The PAF soon learned that early Sidewinders seldom worked if fired at low levels, but despite this the 17 missiles fired gained eight confirmed kills in this 22-day war.

In the Vietnam War, despite the vast numbers of aircraft used on the South Vietnamese and American side, few air combats took place and those were often circumscribed by crippling rules of engagement written in Washington. Suffice to say that the most successful Allied aircraft, by far, was the McDonnell Douglas F-4 Phantom, which flown by the USAF claimed 107 of the air force's 132 claimed



The AA-2 (NATO reporting name 'Atoll') is a Soviet copy of the first generation (AIM-9B) Sidewinder with solid propellant and crude infra-red guidance. It is most effective in high-altitude engagements, and is ineffective when fired at targets approaching head-on or manoeuvring hard. The nature of 'Atoll' makes it possible that the Libyan pilot fired inadvertently.

The Su-22 'Fitter' is a swing-wing variant of the tried and trusted Su-7. With a new wing, engine and avionics the Su-22 is faster and more manoeuvrable, and survivability in a modern air combat environment is much higher.

Beginning what looks like another routine intrusion to test the defences of the US Sixth Fleet, two 'Fitters' turn inwards to keep the Tomcats off their tails. Unexpectedly the Libyan leader fires a heat-seeking 'Atoll' from about 300 m (1,000 ft) range, but this misses the Tomcats.

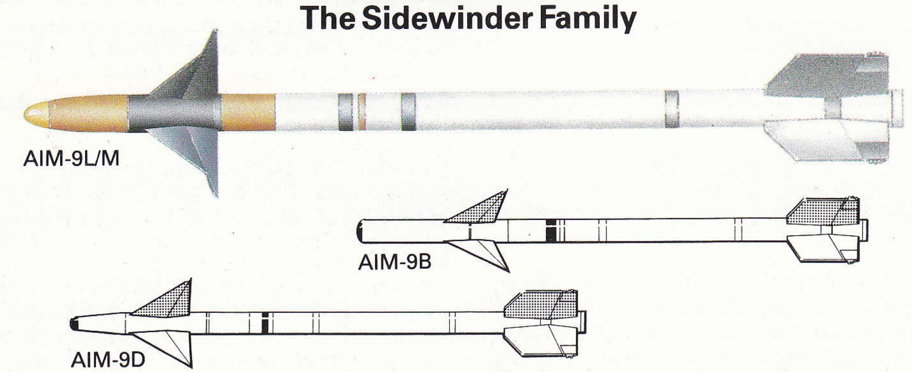
The Libyan wingman pulls into a climbing turn to starboard followed by Commander Kleeman in the leading Tomcat. Simultaneously Lieutenant Musczynski, the wingman, crosses over to follow the Libyan leader.

The Gulf of Sidra Incident (19th August 1981)

During the first day of a US Sixth Fleet exercise in the Mediterranean large numbers of intruding Libyan aircraft were intercepted and escorted clear of the area. The Libyan aircraft did not use their weapons, so the engagements proceeded like a normal peacetime air-combat exercise.

On the second day two F-14 Tomcats from the USS* Nimitz *picked up two unidentified aircraft on radar. The pilot of the leading Tomcat sighted the two aircraft at seven miles and turned towards them to intercept. They were positively identified as Libyan Sukhoi Su-22 'Fitters' at about three miles' range, and seconds later both Tomcat pilots saw the leading Libyan aircraft fire a missile. Under standard rules of engagement the Su-22s were now considered hostile and the Tomcat pilots were cleared to fire without approval from above.

The Sidewinder Family



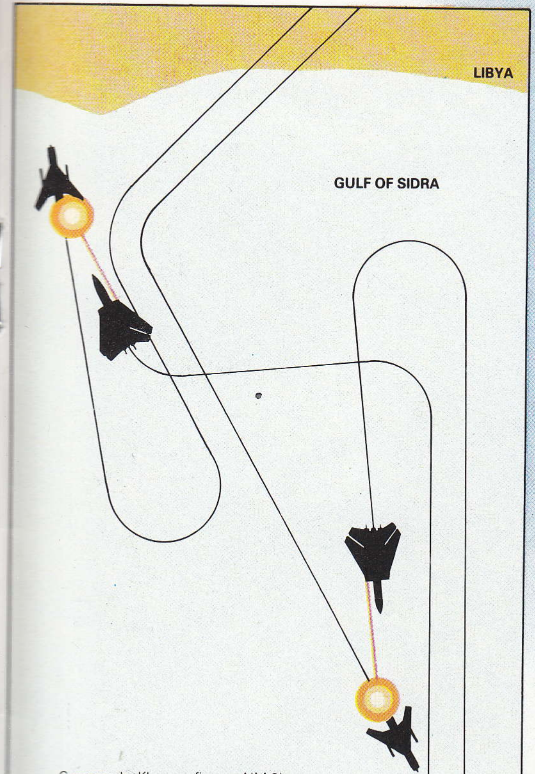
Sidewinder has appeared in numerous guises since 1956, ranging from the all-aspect AIM-9L used by Britain in the Falklands (top) through to the Soviet copy of the Sidewinder, the AA-2 'Atoll'.

victories. How many of these were real, and how many gained with Sidewinders, cannot be stated with assurance, but the dogfight AAM certainly accounted for more than 60 per cent of the F-4 victories. In the US Navy the F-4 gained 13 victories, all well documented, and the older Vought F-8 Crusader gained 19, mostly in the early years, of which 13 were bagged by the AIM-9B or semi-active radar-guided AIM-9C Sidewinder.

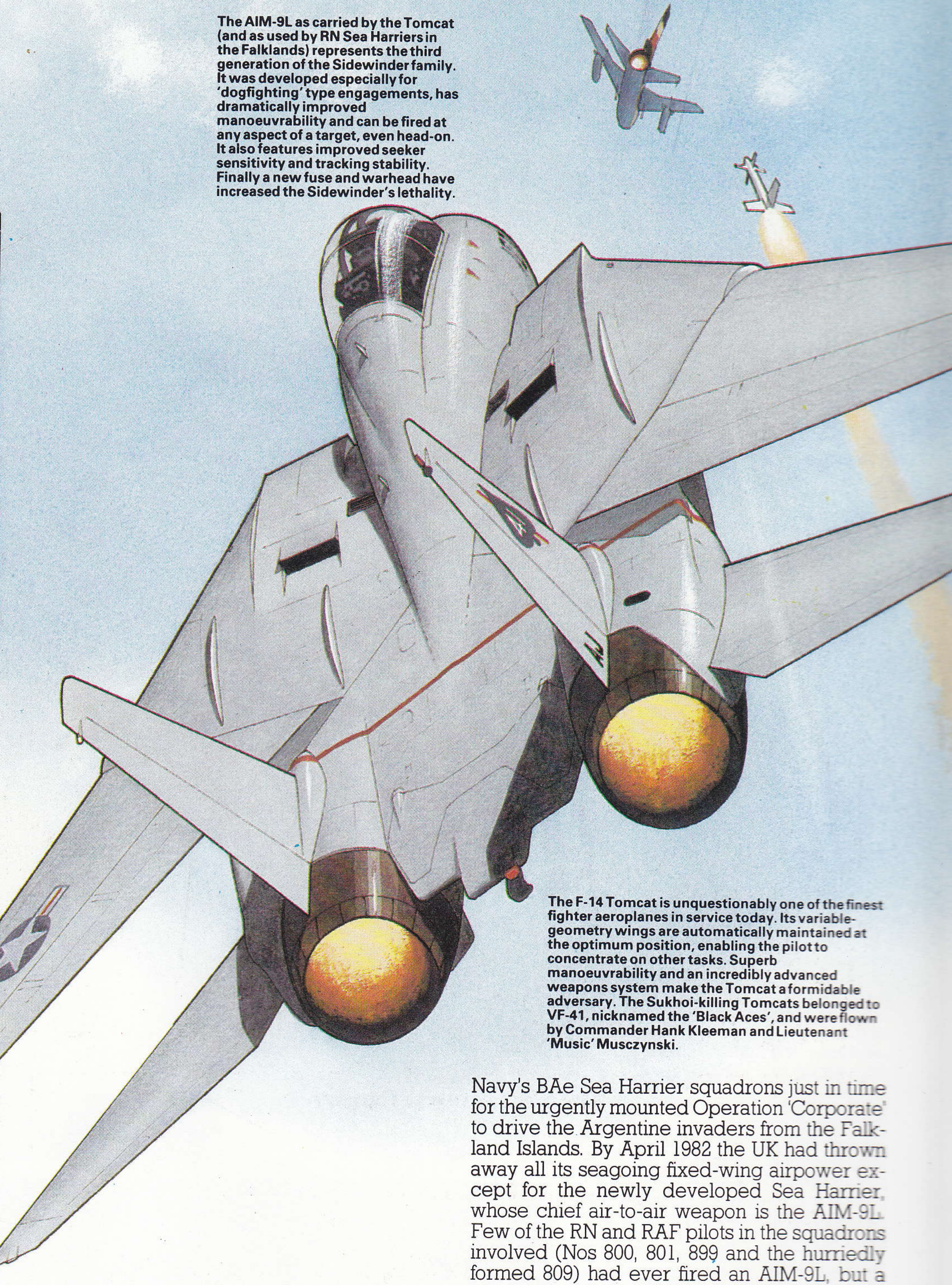
Over the past 30 years many much better Sidewinders have been developed, and the best at present in wide use is the AIM-9L with a totally new guidance system which is sensitive enough to lock on to the heat emission from any fighter-type target from any aspect, including the most difficult head-on aspect. The AIM-9L also has a new motor giving a range of 18 km (11 miles), a much more powerful annular blast fragmentation warhead and a precision-acting proximity fuse with a ring of eight small diode lasers and silicon photo-diode receivers for laser light reflected from the target. The AIM-9L is immediately identified by its long-span pointed control fins, which enable it to outmanoeuvre all fighters under all flight conditions.

The AIM-9L came into service with the Royal

The AIM-9L as carried by the Tomcat (and as used by RN Sea Harriers in the Falklands) represents the third generation of the Sidewinder family. It was developed especially for 'dogfighting' type engagements, has dramatically improved manoeuvrability and can be fired at any aspect of a target, even head-on. It also features improved seeker sensitivity and tracking stability. Finally a new fuse and warhead have increased the Sidewinder's lethality.



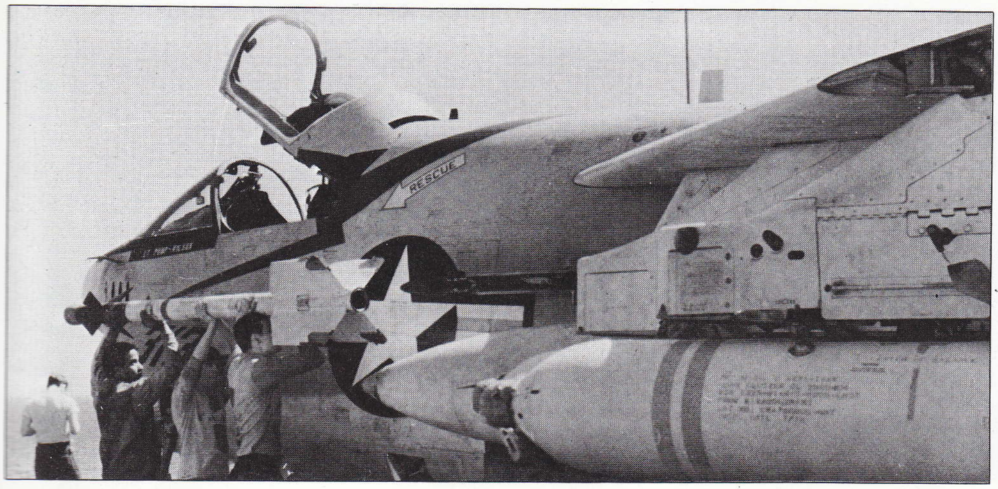
Commander Kleeman fires an AIM-9L Sidewinder, the Libyan pilot ejecting safely as the missile finds its mark. Lieutenant Musczynski fires a Sidewinder at the Libyan leader's six o'clock. The missile impacts and blows off the tail of the Libyan aircraft. The pilot is seen to eject, but no parachute is observed. The Tomcat has scored its first actual combat victories.



The F-14 Tomcat is unquestionably one of the finest fighter aeroplanes in service today. Its variable-geometry wings are automatically maintained at the optimum position, enabling the pilot to concentrate on other tasks. Superb manoeuvrability and an incredibly advanced weapons system make the Tomcat a formidable adversary. The Sukhoi-killing Tomcats belonged to VF-41, nicknamed the 'Black Aces', and were flown by Commander Hank Kleeman and Lieutenant 'Music' Musczynski.

Navy's BAe Sea Harrier squadrons just in time for the urgently mounted Operation 'Corporate' to drive the Argentine invaders from the Falkland Islands. By April 1982 the UK had thrown away all its seagoing fixed-wing airpower except for the newly developed Sea Harrier, whose chief air-to-air weapon is the AIM-9L. Few of the RN and RAF pilots in the squadrons involved (Nos 800, 801, 899 and the hurriedly formed 809) had ever fired an AIM-9L, but a few were able to get in practice against flare targets on the long journey south.

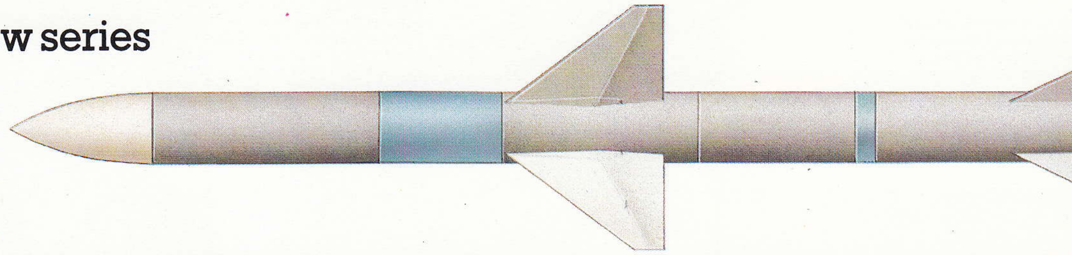
Air combats began on 1 May when Flight Lieutenant Paul Barton bagged a Dassault-Breguet Mirage. He suddenly got into a firing position, quickly achieved a positive lock, released the missile and watched the Mirage explode in a fireball. The few pilots experienced with earlier Sidewinders soon found that the AIM-9L is much more lethal. Time after time the sequence was the same, ending a few seconds later with a fireball. Altogether 27 Sidewinders were fired before the surrender on 14 June, almost all in four hectic engagements. The result was 20 confirmed kills, three probables, and one Mirage last seen heading into thick cloud with a Sidewinder on its tail.



An AIM-9 Sidewinder is loaded onto an A-7E Corsair II aboard USS* Nimitz *(CVN 68) in the Indian Ocean. The AIM-9D being loaded here is 2.87-m (9.42-ft) long and weighs 88 kg (195 lb).

USA

AIM-7 Sparrow series



The Raytheon AIM-7 Sparrow is radar-homing and has all-weather, all-altitude operational capability. The Sparrow may also be used as an anti-shipping missile, either air- or surface-launched.

The **Sparrow I** radar beam-riding air-to-air missile began life in 1946 as Sperry Gyroscope's Project Hot Shot for the US Navy. By 1951 full engineering development had begun and in 1956 the weapon had entered service. In 1955 Douglas started limited development of a **Sparrow II** with active radar-homing, but this was cancelled in the following year. In the meantime Raytheon started development of the **Sparrow III** variant which used essentially the same missile body as the Sparrow II but with a semi-active radar homing system. The Sparrow III entered service with the US Navy in 1958 and has been progressively modified ever since. In 1960 the US Air Force also adopted the SARH Sparrow to arm its new McDonnell F-110 (later F-4) Phantom interceptor. The main production model, the **AIM-7E** (over 25,000 built), was followed into service by a redesigned version, the **AIM-7F**, in 1977 for use on the McDonnell Douglas F-15 Eagle and F-18 Hornet fighters. In comparison with the AIM-7E the new missile has a considerably enhanced performance envelope, a more powerful rocket motor and a smaller all solid-state guidance system with conical-scan seeker head. To improve its own AIM-7E missiles' performance the UK in 1969 embarked on the development of an I-band monopulse seeker head with markedly improved ECCM features in comparison with the original American seeker. The new missile was put together by British Aerospace as the **Sky Flash**, and entered service with the Royal Air Force in 1978 initially for the McDonnell Douglas Phantom FG.Mk 1 and FGR.Mk 2 and then the Panavia Tornado F.Mk 2 when the latter comes into service. In 1982 the US manufacturer of the Sparrow (Raytheon and GD Pomona) switched to building the latest version, the **AIM-7M**, which is an AIM-7F with a new seeker head comparable in operation and performance with the type on the Sky Flash.

The Sparrow saw considerable combat use in Vietnam with the US Air Force and US Navy, and also with Iran against Iraq during the current Gulf War and with Israel against the Arabs in the post-1967 conflicts. The results in each were not exactly inspiring, and the Israelis still maintain that they prefer to use short-range missiles and cannon rather than SARH missiles. The Sparrow, in all its versions, is used by Canada, Greece, Iran, Israel, Italy, Japan, Saudi Arabia, South Korea, Spain, Turkey, UK, USA (air force, navy and marine corps) and West Germany. The British Sky Flash derivative is operated by Sweden (**Rb71**) and UK.

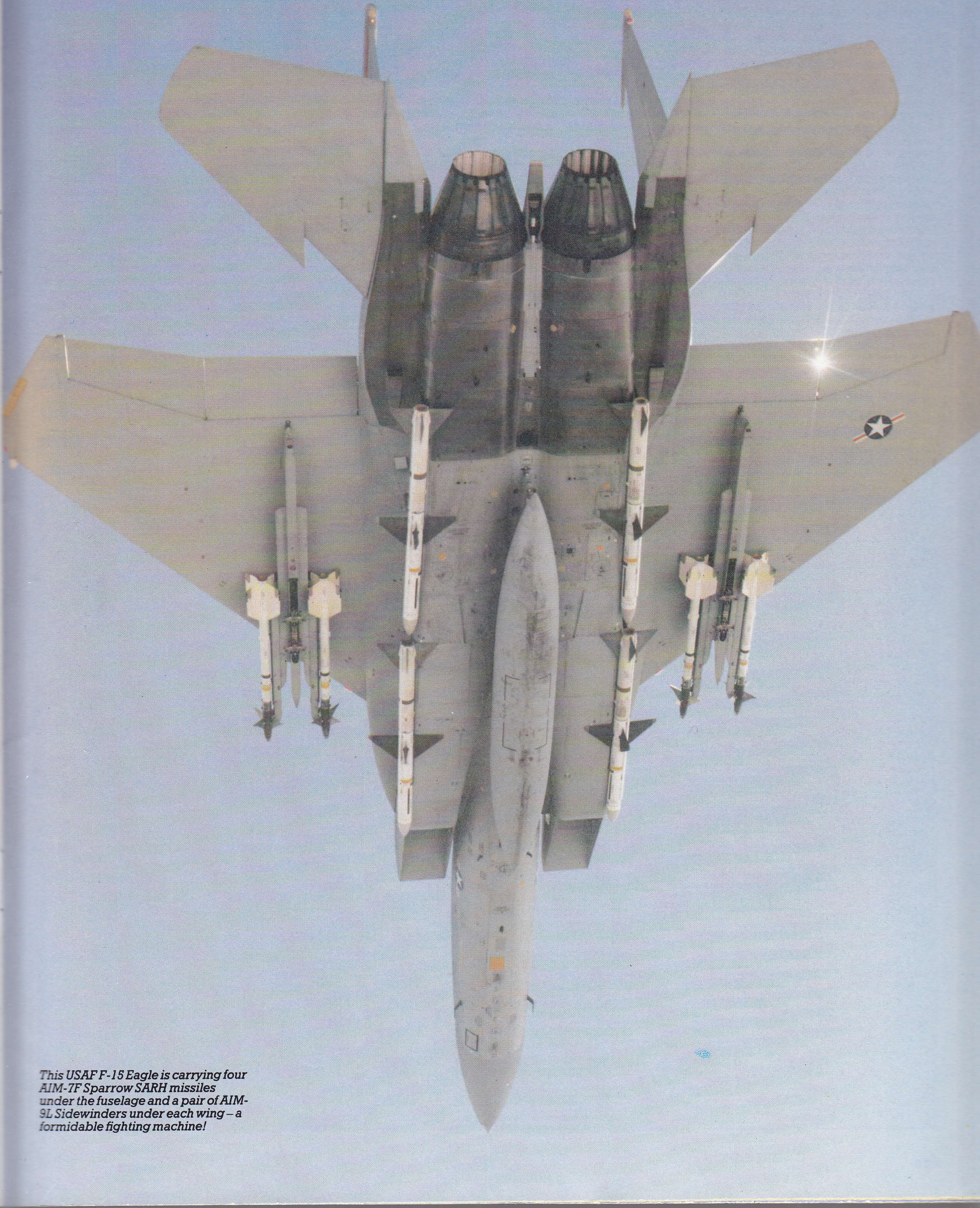
Specification
AIM-7E
Dimensions: length 3.66 m (12 ft 0 in); span 1.02 m (3 ft 4 in); body diameter 0.203 m (8 in)
Launch weight: 205 kg (451.9 lb)
Performance: speed Mach 4.0; range 30-37 km (18.6-23 miles) depending on the launch platform's speed
Warhead: 29.5-kg (65-lb) HE fragmentation with contact, delay action and proximity fuses

Specification
AIM-7F
Dimensions: length 3.66 m (12 ft 0 in); span 1.02 m (3 ft 4 in); body diameter 0.203 m (8 in)
Launch weight: 228 kg (502.6 lb)
Performance: speed Mach 4.0; range 44-70 km (27.3-43.5 miles) depending on the launch platform's radar capability and speed
Warhead: 39-kg (86-lb) HE fragmentation with contact, delay action and proximity fuses

Specification
AIM-7M
Dimensions: length 3.68 m (12 ft 0.88 in); span 1.02 m (3 ft 4 in); body diameter 0.203 m (8 in)
Launch weight: 228 kg (502.6 lb)
Performance: speed Mach 4.0; range 44-70 km (27.3-43.5 miles) depending on the launch platform's radar capability and speed
Warhead: 39-kg (86-lb) HE fragmentation with contact, delay action and proximity fuses

Right: A US Navy crew loads an AIM-7F Sparrow onto an F-14 Tomcat of the Pacific Missile Test Center. The Sparrow is carried by F-14, F-15, F-18 and F-4 aircraft and has been used in action in Vietnam and the Middle East.

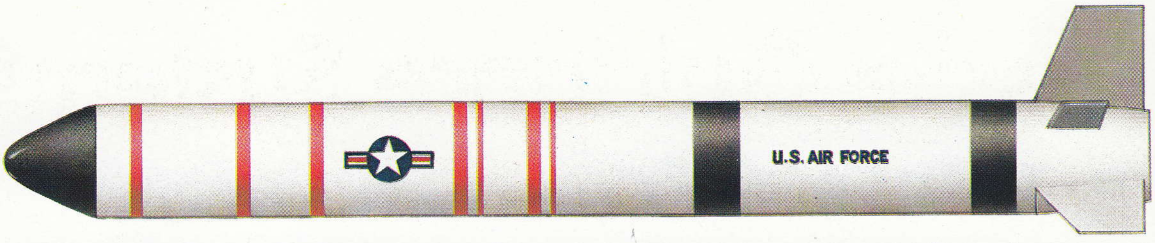
Below: An AIM-7 Sparrow shoots away from a US Air Force F-4D Phantom. This combination has not been a great success in Vietnam or the Middle East, short-range IR missiles achieving better kill probabilities.



This USAF F-15 Eagle is carrying four AIM-7F Sparrow SARH missiles under the fuselage and a pair of AIM-9L Sidewinders under each wing – a formidable fighting machine!

USA

Vought ASAT



The Vought ASAT is a small high-technology air-launched anti-satellite (ASAT) missile capable of destroying enemy satellites at orbital altitudes. ASAT does not have an explosive warhead, the target being destroyed by the energy released in the collision between it and the missile.

Destined to be the deployable offensive weapon component of the United States Space Defense Operations Command within the North American Aerospace Defense Command (NORAD) network, the **ASAT** is under engineering development by Vought to meet a requirement for an air-launched weapon to engage enemy satellites above the earth's atmosphere. ASAT is a two-stage solid-propellant rocket. The first stage is 0.4445 m (17.5 in) in diameter, with two small fixed and three large moveable fins for control during atmospheric ascent; this module is based on the Boeing Short Range Attack Missile. The second stage is 0.503 m (19.8 in) in diameter and is fitted with an Altair III rocket motor and small hydrazine thrusters for attitude control. At its forward end is the 305 mm by 330.2 mm (12 by 13 in) Vought Project 1005 Miniature Vehicle (MV) that attacks the satellite target once the latter has been acquired against the background of space by the MV's onboard sensor. This latter is an infra-red system using eight small telescopes to see its target. Once a lock-on is achieved the MV is detached on an interception course. The MV fires sequentially 56 small solid-propellant rocket cylinders in its outer shell during the engagement phase whilst under control of the very sophisticated IR electronic guidance package, which has no moving parts. The target is destroyed by the energy released in the collision between it and the MV, which at impact will be travelling at about 49375 km/h (30,680 mph). The energy output of the impact is said to be the equivalent of hitting the satellite with a shell from a 406-mm (16-in) naval gun.

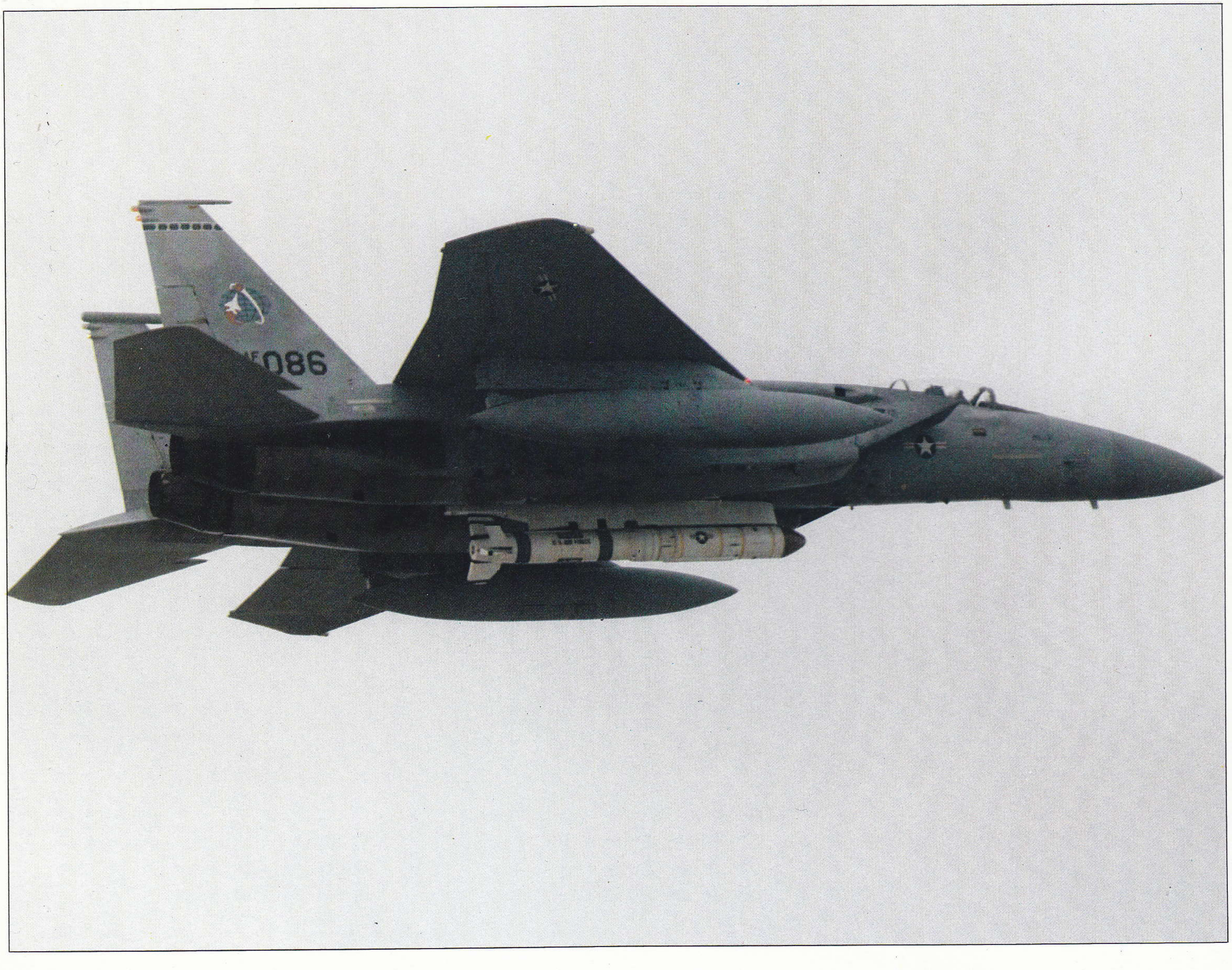
The carrier for ASAT is a modified McDonnell Douglas F-15 Eagle in which the 20-mm ammunition container is replaced by an electronics package and a new centreline fuselage pod is fitted with associated electronics. The total modifications take less than 6 hours. For most attack profiles against low Earth-orbit satellites the F-15 will fly straight and level at subsonic speeds for the ASAT launch whilst for higher orbit targets the F-15 will perform a supersonic climb release of the ASAT. Two 24-plane squadrons have been designated as ASAT units, the 318th Fighter Squadron at McChord AFB, Washington State, and the 48th Fighter Squadron at Langley AFB, Virginia, these units being chosen because of the NORAD F-15 basing plans, Soviet satellite orbital inclinations and the requirement for ASAT boost section debris to fall into the ocean. The ASAT system is expected to be operational by the late 1980s or early 1990s, the first test firing of components from an F-15 being undertaken in January 1984.

Specification

ASAT

Dimensions: length 5.40 m (17 ft 8.6 in); body diameter 1st stage 0.4445 m (1 ft 5.5 in) and 2nd stage 0.530 m (1 ft 7.8 in)
Launch weight: 1194 kg (2632.3 lb)
Performance: speed hypersonic; range can engage satellites out to 1000-km (621-mile) orbital altitude
Warhead: non-explosive collision-type Miniature Vehicle

Below: ASAT will be carried by two squadrons of McDonnell Douglas F-15 Eagles based at Langley AFB, Virginia, from about 1987. Firing trials began in 1983. For higher orbital targets the ASAT will normally be launched during a supersonic zoom climb and will be propelled initially by the Altair rocket motor. When this separates small propellant rocket motors will provide course corrections until impact.



Missile Guidance Systems

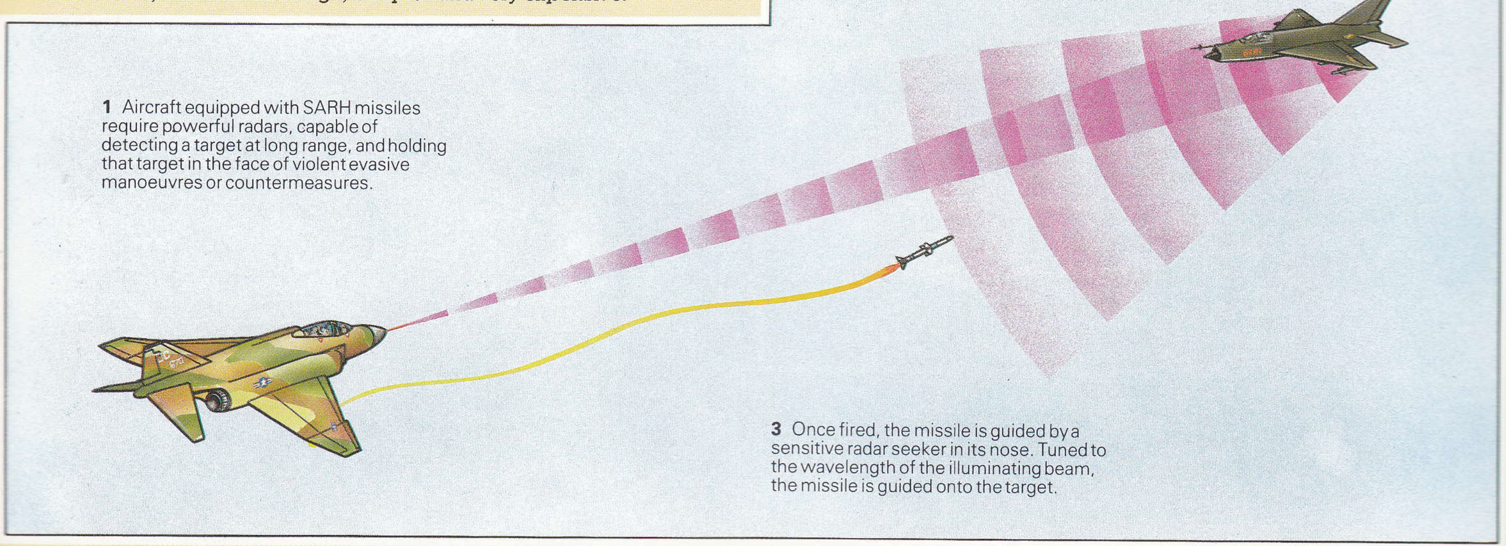
Air-to-air missiles generally use either semi-active radar homing (SARH) or infra-red (IR) homing. SARH is used for large, long-range missiles and requires a launch aircraft with powerful radar to 'illuminate' the target. IR missiles are smaller, with a shorter range, and allow 'fire and forget' operation by less sophisticated aircraft.

The most commonly used guidance systems in air-to-air missiles today are the semi-active radar homing (SARH) and the infra-red (IR) homing types. The former is generally used for the larger and longer-ranged missiles, and requires the launch platform to have a radar that is capable of detecting the target at long ranges and then holding it in a continuous-wave radar beam despite any violent manoeuvring that it may be doing. With the target thus 'illuminated', a missile is fired towards it, the missile carrying in its nose a sensitive radar seeker tuned to that radar's particular signal. The missile then literally follows the radiation reflected by the target with its sensitive radar receiver until it impacts or passes close enough for a proximity fuse to be triggered. One variation of this can be found in the longest-range missile, the American Phoenix, which employs a SARH Doppler mode to bring it to within the acquisition range of its own onboard radar for the terminal engagement phase. Such a system allows six missiles to be in flight simultaneously against separate targets, the 'illuminating' radar in the launch aircraft being switched between the targets and the missiles having to time-share the SARH guidance mode. This effectively precludes such guidance throughout the whole flight, although this problem is believed to have been solved in the Phoenix's latest version.

For close-range air combat the IR seeker is used to allow the 'fire-and-forget' operation. IR seeking generally permits a smallish missile with a seeker that homes on to the shorter wavelength IR radiation emitted by the hottest portions of any modern jet, namely the jet pipe and final propulsion stage. For many years seeker technology required that the missile be fired from astern of the target in good weather to ensure a hit, but the most recent missiles have much more sensitive IR seekers that permit not only lock-on at longer ranges against a target at any aspect (including head-on), but also a markedly improved capability to engage in cloudy or rainy weather. Even more recent is the South African development of using helmet-mounted sights to acquire targets for IR missiles in dogfights, whilst the slaving of IR seekers to aircraft radars is also being pursued for the same purpose.

Semi-active radar homing

Radar homing missiles give aircraft the capacity to destroy targets beyond visual range. Most radar-guided missiles in use today require an external radar source, usually provided by the launching aircraft. Missiles with their own radar exist, but tend to be large, complex and very expensive.



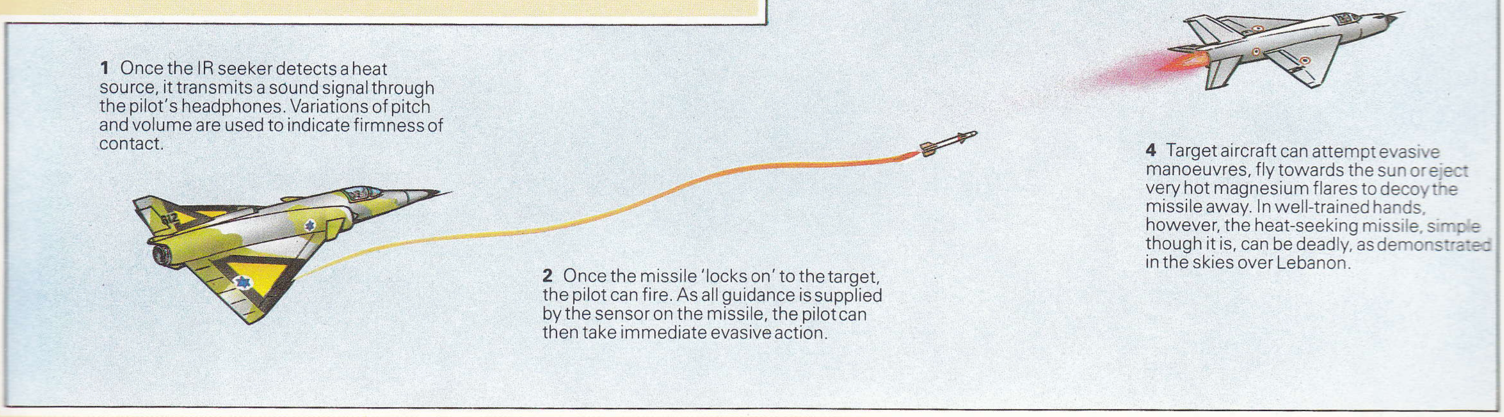
1 Aircraft equipped with SARH missiles require powerful radars, capable of detecting a target at long range, and holding that target in the face of violent evasive manoeuvres or countermeasures.

2 Once a target is detected, it is 'illuminated' by a continuous wave radar beam emanating from the parent aircraft.

3 Once fired, the missile is guided by a sensitive radar seeker in its nose. Tuned to the wavelength of the illuminating beam, the missile is guided onto the target.

Infra-red homing ('fire and forget')

Infra-red homing missiles rely for guidance upon the simple fact that jet engines generate large amounts of heat. The sensitive IR telescope in the nose of a typical modern missile is capable of detecting such a heat source from a distance of several kilometres.



1 Once the IR seeker detects a heat source, it transmits a sound signal through the pilot's headphones. Variations of pitch and volume are used to indicate firmness of contact.

2 Once the missile 'locks on' to the target, the pilot can fire. As all guidance is supplied by the sensor on the missile, the pilot can then take immediate evasive action.

3 In flight, the seeker head remains locked on to the target. In the AIM-9 Sidewinder and its derivatives, flight is usually controlled by cruciform canard fins.

4 Target aircraft can attempt evasive manoeuvres, fly towards the sun or eject very hot magnesium flares to decoy the missile away. In well-trained hands, however, the heat-seeking missile, simple though it is, can be deadly, as demonstrated in the skies over Lebanon.

Specification

Sky Flash

Dimensions: length 3.68 m (12 ft 0.88 in); span 1.02 m (3 ft 4 in); body diameter 0.203 m (8 in)

Launch weight: 193 kg (425.5 lb)

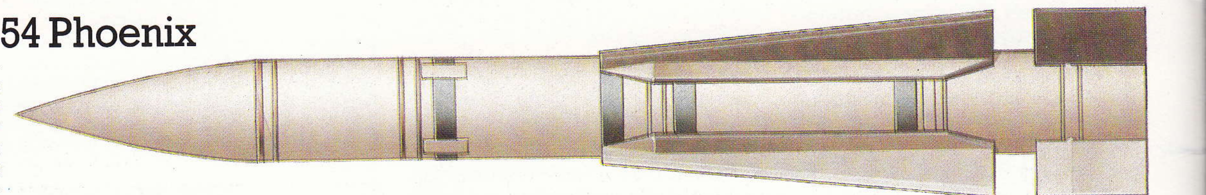
Performance: speed Mach 4.0; range 30-37 km (18.3-23 miles) depending on the launch platform's speed

Warhead: 39.5-kg (65-lb) HE fragmentation with contact, delay action and proximity fuse

A British Aerospace Sky Flash is fired from a US Navy Phantom. The Sky Flash is in service with the RAF and the Swedish air force, and is essentially a Sparrow with a new semi-active radar-homing head developed by Marconi and a new Thorn-EMI advanced radar proximity fuse.

USA

Hughes AIM-54 Phoenix



The Hughes AIM-54 Phoenix is matched to the pulse-doppler AWG-9 radar and is carried solely by the Grumman F-14 Tomcat. The AWG-9 is able to track multiple targets, at high and low altitudes, in all weather conditions, and simultaneously launches six Phoenix missiles.

Development of the long-range **Hughes AIM-54 Phoenix**, under the designation **AAM-N-11**, was started by Hughes Aircraft in 1960 as a follow-on from the 213-km (132-mile) range GAR-9 (later AIM-47A) Falcon derivative that had been intended to arm the defunct US Air Force's Mach 3.2 North American F-108 interceptor. The new missile was to be matched to the US Navy's General Dynamics F-111B interceptor with the pulse-Doppler AWG-9 radar system. Such a combination flew in March 1969 and successfully engaged two targets simultaneously during a test trial. With the cancellation of the F-111B programme the Grumman F-14 Tomcat was substituted as the carrier for the radar system/missile combination. First deliveries of the AWF-9 took place in 1970, with production of the **AIM-54A** beginning in 1973. In 1977 a modified missile, the **AIM-54B**, was placed in limited production with final deliveries being made in 1980. At the same time as production of the AIM-54B began, the development of a completely updated version, the **AIM-54C**, was started to meet new operational requirements and deny the Soviets any advantage gained by the compromising of the AIM-54A in Iran. The AIM-54C has all-digital electronics, a new strapdown inertial reference system, a solid-state radar, and considerably enhanced ECCM systems. Following successful firing trials the missile entered production in 1981, first deliveries being made to the US Navy in October of that year.

The Phoenix is designed to provide a single-aircraft air-defence cover that exceeds 12,000 square miles (31000 km^2) from altitudes just above sea level to 24810 m (81,400 ft) in the AIM-54A version or to 30490 m (100,000 ft) in the AIM-54C version. With six missiles carried, the Tomcat can simultaneously launch and engage up to six individual aircraft or missile targets at maximum missile range and various altitudes. Coupled with the Grumman E-2C Hawkeye AEW aircraft, the Tomcat/Phoenix combination provides the major American carrier battle groups with effective defence against the Soviet navy's aircraft and missile attack units.

Flight control is exercised by cruciform rear fins, and during its cruise phase the Phoenix adopts a sample-data SARH mode of guidance, the AWG-9 providing target illumination for each missile. At a range of some 20 km (12.5 miles) from the target, the missile switches to its own nose-mounted planar pulse-Doppler radar for the terminal phase of the flight. The missile's own radar can also be used for direct guidance in short-range engagements rather than using the aircraft's own radar and, in the latest missile version, it is said that the SARH mode of guidance can now be used throughout the engagement to defeat countermeasures. Further missile improvements are also under investigation for the 1990s.

Specification

AIM-54

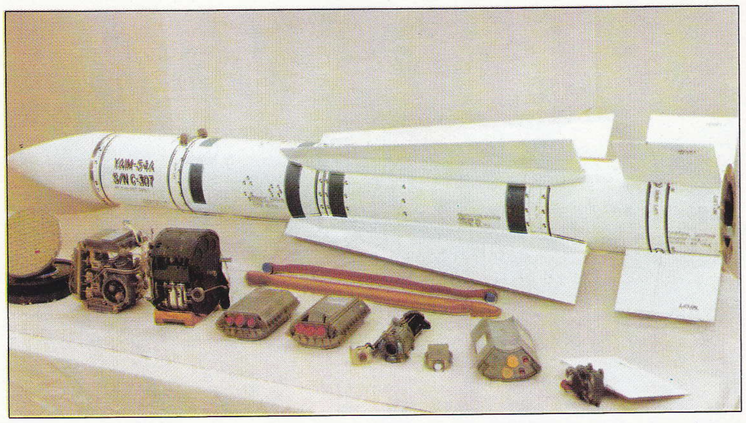
Dimensions: length 4.01 m (13 ft 1.8 in); span 0.925 m (3 ft 0.4 in); body diameter 0.38 m (1 ft 3 in)

Launch weight: 447 kg (985 lb)

Performance: speed AIM-54A Mach 4.3 and AIM-54C Mach 5; range AIM-54A 3.9-136 km (2.4-85 miles) and AIM-4C 3.5-148 km (2.2-92 miles)

Warhead: 60-kg (132-lb) HE fragmentation with delay action, impact and active-radar proximity fuse

An AIM-54 Phoenix with its main components. From the left are: seeker, transmitter/receiver unit, electronics unit, electrical conversion unit, autopilot, hydraulic power supply, rear antenna mixer, battery, and hydraulic actuator.



Below: A Grumman F-14A Tomcat test-fires an AIM-54 Phoenix. The Iranian revolution and subsequent compromising of the AIM-54A led to the development of a much-improved and enhanced Phoenix, the AIM-54C.

NATO's new generation of air-to-air missiles - AMRAAM and ASRAAM

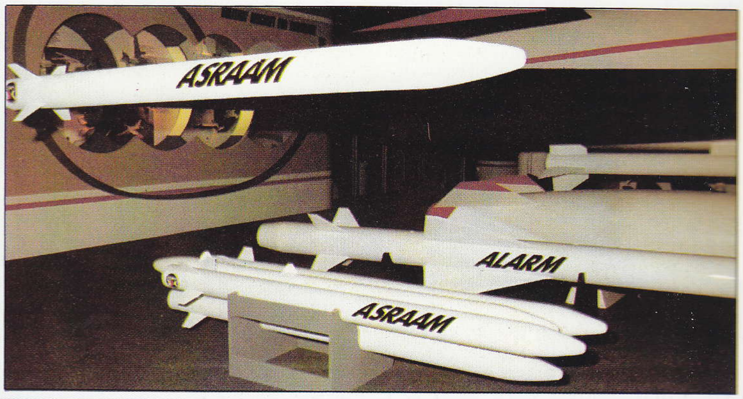
Both the Sparrow and the Sidewinder missile have undergone a great deal of development since they were first introduced, but neither is really capable of absorbing further improvement. For this reason the United States embarked on a high-priority replacement programme for both families, the replacements being respectively AMRAAM and ASRAAM.

Because of the age of the Sparrow and Sidewinder missile families the United States embarked on a high-priority replacement schedule for both weapon series in the 1970s. By 1980 this effort had developed into the Advanced Medium-Range Air-to-Air Missile (AMRAAM) designed under the auspices of a joint US Air Force and US Navy programme, and the Advanced Short-Range Air-to-Air Missile (ASRAAM) which had become a primarily European NATO project between West Germany, the UK and the USA.

After evaluation of five competing company groups, Hughes Aircraft was picked out of a shortlist of two to build the AMRAAM. This is a missile in the same size bracket as the Sidewinder but with an advanced Sparrow-type performance and flight controls. Designated AIM-120A, it is a 'fire-and-forget' system, the missile flying out towards the target under the control of a pre-programmed strapdown inertial-guidance package. Once at the predicted target location a K-band active-radar travelling-wave tube seeker head is activated for the terminal homing phase. For long-range engagements the aircraft can update the missile's flight path by transmitting target-location data (with an L-band transmitter) to the missile's guidance package. To ensure short flight times a high-impulse solid-propellant rocket motor has been developed. Up to six rounds can be fired in rapid succession against separate targets, the only launch requirement being that the aircraft must have a track-while-scan radar to allow the multiple-target engagement capability. The first fully guided AIM-120A test rounds were successfully launched in the early 1980s, testing of full-scale development rounds being due in 1984. Service introduction is scheduled for 1986.

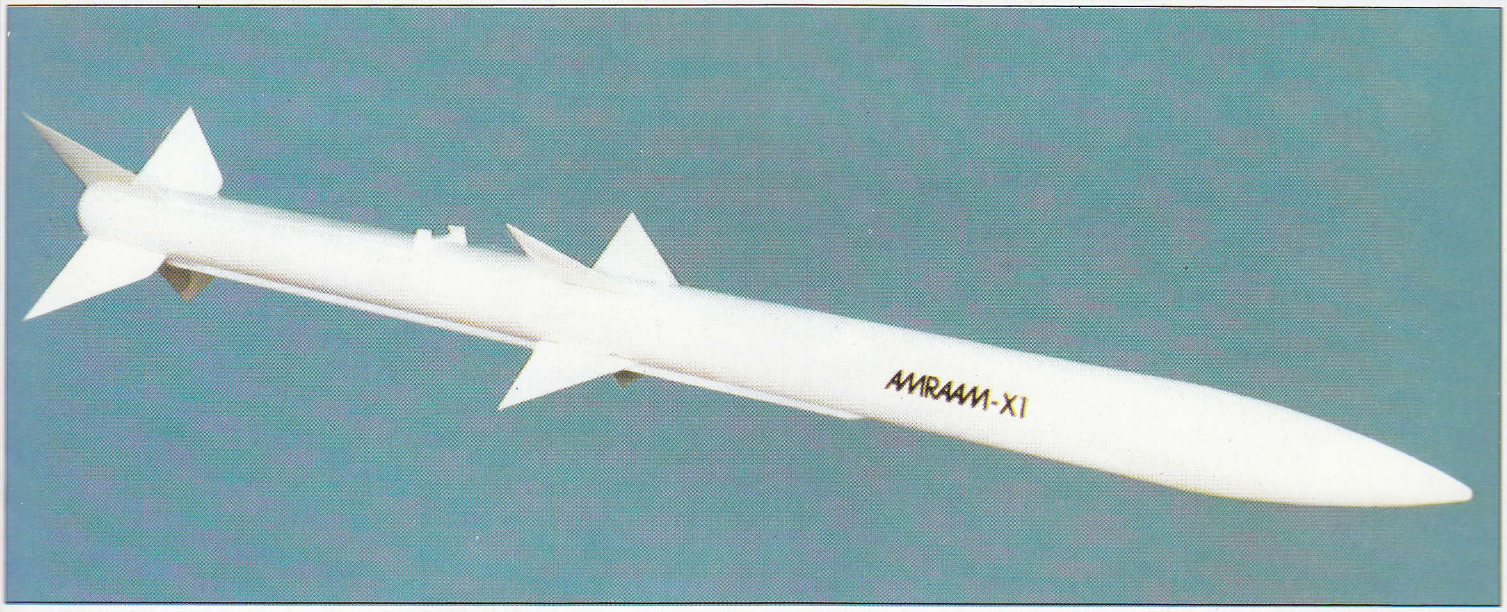
The ASRAAM finished its feasibility study phase in 1983, with the project definition stage extending into 1984. Actual engineering development is to start in 1985 and finish in 1990, with the first production rounds to be delivered soon after that date. The missile is intended to be cheap, to have a minimum maintenance requirement, and to possess both an all-aspects engagement envelope and a high kill probability. The latter is to be sufficiently high to permit development without proximity fusing and large warhead. In order to achieve some of these goals a thrust-vector flight-control system and an advanced staring focal plane IR guidance seeker seems likely. To avoid problems with US congressional requirements for licence-built weapons and the American 'not invented here' syndrome, the two European companies involved with ASRAAM (British Aerospace and Bodenseewerke Gerätetechnik) signed a technical co-operation agreement with Hughes Aircraft in September 1982.

Below: US Air Force crewmen instal wings and tailfins on a mock-up of the Hughes AMRAAM (Advanced Medium-Range Air-to-Air Missile) mounted on a McDonnell Douglas F-15 Eagle fuselage station. Testing of full-scale development rounds is due this year, with service introduction scheduled for 1986.



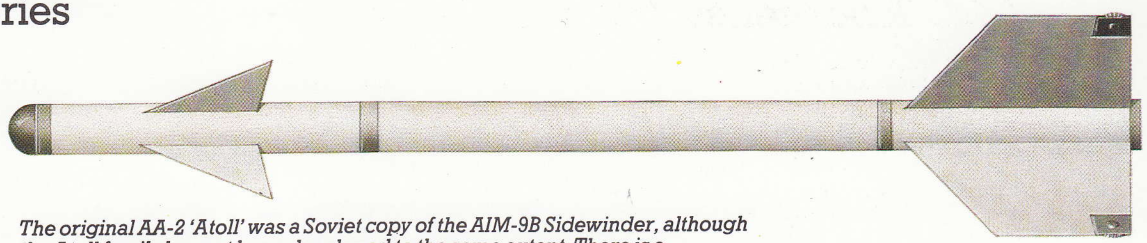
Above: Mock-ups of the British Aerospace ASRAAM (Advanced Short-Range Air-to-Air Missile) are displayed with a mock-up of the British Aerospace Agile Combat Aircraft at the 1982 Farnborough show. The first production rounds are due to be delivered in 1990.

Below: Another mock-up of the Hughes AMRAAM. The missile is a 'fire and forget' system, flying out towards the target under control of a pre-programmed inertial guidance system before an active radar seeker head is activated for the terminal homing phase.



USSR

AA-2 'Atoll' series



The original AA-2 'Atoll' was a Soviet copy of the AIM-9B Sidewinder, although the Atoll family has not been developed to the same extent. There is a semi-active radar homing model known as Advanced Atoll, but this has not been widely produced.

'Atoll' is the NATO reporting name assigned to a Soviet air-to-air missile family that in its first-generation form closely resembled the early Sidewinders, primarily because a sample of the latter had been obtained by the Communist Chinese air force in 1958, when one of its Mikoyan-Gurevich MiG-15s flew home with a dud Sidewinder lodged in its fuselage after an air battle with Taiwanese fighters. According to American intelligence sources, there are four versions, the **AA-2a, AA-2b, AA-2c** and **AA-2d**. It is highly likely that the AA-2a and AA-2b are IR and SARH versions of the first-generation model, whilst the AA-2c and AA-2d are the corresponding versions of the slightly more reliable second-generation **AA-2-'Advanced Atoll'** variant. The early IR model has seen widespread combat service and its performance is reckoned to be relatively poor. The 'Atoll' is standard armament for the early (two missiles) and late (four missiles) model MiG-21 'Fishbed' interceptor, and has been widely exported. Other aircraft seen with the missile include the MiG-17 'Fresco' (2), MiG-19 'Farmer' (2), MiG-23 'Flogger' (4), Sukhoi Su-20/22 'Fitter' (2), Sukhoi Su-11 'Fishpot' (2) and the Yakovlev Yak-28P 'Firebar' (2). In the Soviet air force and several Warsaw Pact countries the AA-2 is being replaced by the AA-8 Aphid. Current operators of the 'Atoll' series are Afghanistan, Albania, Algeria, Angola, Bangladesh, Bulgaria, China (own version), Cuba, Czechoslovakia, East Germany, Egypt, Ethiopia, Finland, Hungary, India (licence built), Iraq, Laos, Libya, Madagascar, Mongolia, Mozambique, Nigeria, North Korea, North Yemen, Peru, Poland, Romania, Somalia, South Yemen, Sudan, Syria, Tanzania, USSR, Vietnam, Yugoslavia and Zambia.

Specification

AA-2 series

Dimensions: length IR types 2.80 m (9 ft 2.24 in) and SARH types 3.10 m (10 ft 2.05 in); span 0.53 m (1 ft 8.87 in); body diameter 0.12 m (4.72 in)

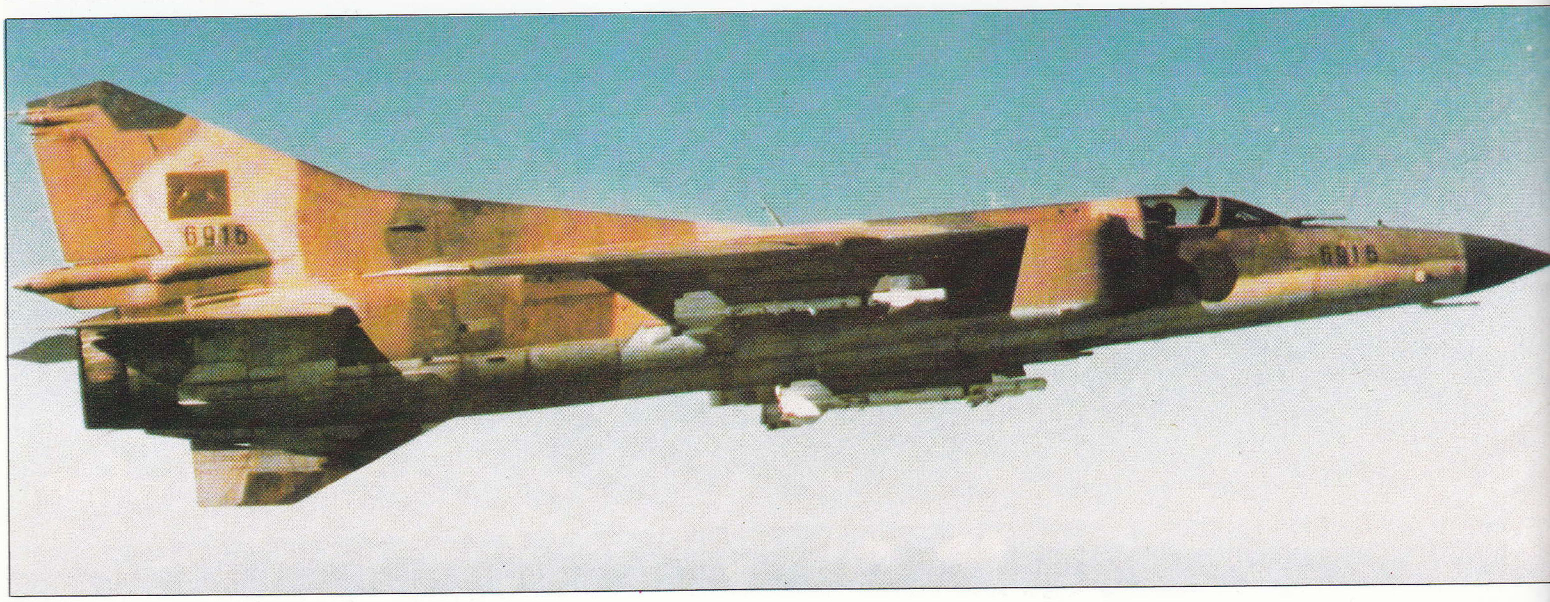
Launch weight: IR types 70 kg (154.3 lb) and SARH types 75 kg (165.3 lb)

Performance: speed Mach 2.5; range IR 1st generation 5.7 km (3.54 miles) and 2nd generation 8 km (5 miles); range SARH 1st generation 8 km (5 miles) and 2nd generation 10 km (6.2 miles)

Warhead: 6 kg (13.2 lb) HE fragmentation with impact and delay action fuses

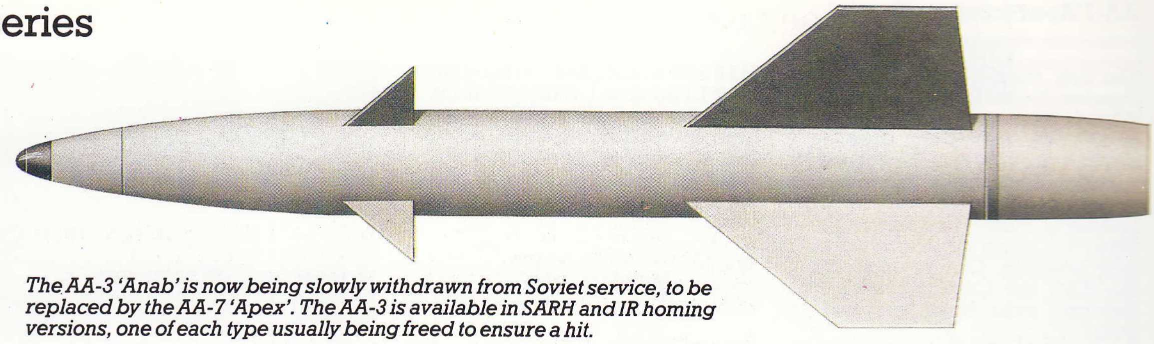
Below: A MiG-23 'Flogger-B' of the Soviet Frontal Aviation carries AA-2 'Atoll' and AA-2-2 'Advanced Atoll' air-to-air missiles. The AA-2 is operated by other nations, and is the Eastern bloc's closest equivalent to the Sidewinder.

Bottom: A Libyan air force MiG-23 'Flogger-E' armed with four standard AA-2 'Atoll' IR homing missiles. The 'Atoll' is one of the few Soviet air-to-air missiles which was not developed specifically for a certain type of aircraft.



USSR

AA-3 'Anab' series



The AA-3 'Anab' is now being slowly withdrawn from Soviet service, to be replaced by the AA-7 'Apex'. The AA-3 is available in SARH and IR homing versions, one of each type usually being freed to ensure a hit.

The solid-propellant **AA-3 'Anab'** is a Soviet second-generation air-to-air missile and was the first all-weather type to be included in the Soviet air force's inventory. Built in both IR and I-band SARH versions, it is normally carried by the RP-11 'Skip Spin'-equipped Sukhoi Su-11 'Fishpot-C', and is also seen on the Sukhoi Su-15 'Flagon' and the Yakovlev Yak-28P 'Firebar' interceptors, all of which carry two AA-3s. The SARH version has its target illuminated by the 'Skip Spin' radar operating in a continuous-wave mode, the aircraft usually launching a missile of each type to improve the hit probability. It was 'Anabs' from Su-15 'Flagons' that shot down both the South Korean Boeing 707 and Boeing 747 jet airliners in recent years, although apparently several missiles had to be fired in order to achieve a hit in both cases. Flight control is exercised by four cruciform canard fins, and there is a large cruciform wing assembly at the tail. From 1972 advanced versions of both variants were in production, although the nature of these improvements has never been revealed. Production finished in the late 1970s after several thousand had been built exclusively for Soviet service, and the AA-3's place is now being taken by the AA-7 'Apex'.

Specification

AA-3 series

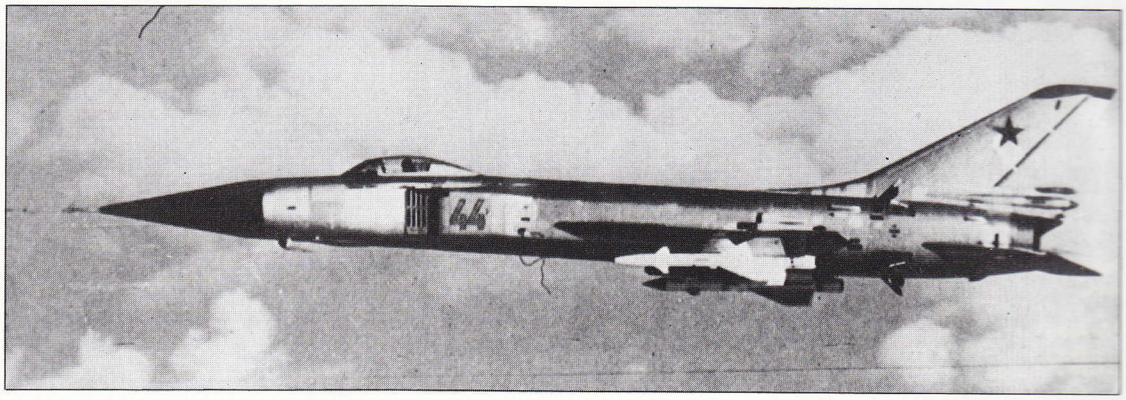
Dimensions: length IR version 4.10 m (13 ft 5.42 in) and SARH version 4.00 m (13 ft 1.48 in); span 1.30 m (4 ft 3.2 in); body diameter 0.28 m (11.02 in)

Launch weight: 275 kg (606.3 lb)

Performance: speed Mach 2.5; range IR version 20 km (12.4 miles) and SARH version 30 km (18.65 miles)

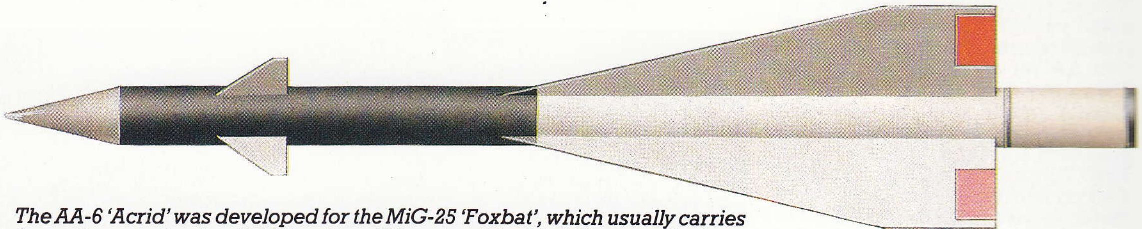
Warhead: 30 kg (66 lb) HE fragmentation with impact and proximity fuses

A Soviet Sukhoi Su-15 'Flagon' armed with AA-3 'Anab' air-to-air missiles; this is thought to be the combination which despatched the Korean Boeing 747 in September 1983.



USSR

AA-6 'Acrid'



The AA-6 'Acrid' was developed for the MiG-25 'Foxbat', which usually carries four of the missiles, two SARH and two IR homing. The AA-6, like most Soviet missiles, is ripple-fired in pairs at a single target to improve kill probability.

Designed in the late 1950s and early 1960s as a pure long-range medium- to high-altitude bomber killer, the solid-propellant **AA-6 'Acrid'** entered service with the Soviet air force in the early 1970s as the largest air-to-air missile fielded by any nation to date. It is the nearest Soviet equivalent to the American Phoenix missile and is the primary armament for the Mikoyan-Gurevich MiG-25 'Foxbat' Mach 2.8 interceptor, which carries four missiles on underwing pylons (two of the IR version on the inner pylons and two of the SARH version on the outer pylons). The GCI-controlled 'Foxbat' uses its own 'Fox Fire' radar to illuminate the target for the SARH missiles, which have an inertial or autopilot mid-course guidance phase. As with nearly all Soviet missiles, the standard practice is to ripple-fire the 'Acrids' in pairs (IR version followed by SARH version) at a single target to improve the kill probability. The 'Acrid' has also been exported outside the Soviet Union to those countries which have the 'Foxbat-A' interceptor in service, namely Algeria, Iraq, Libya and Syria. Improvements have now been made, and it is expected that the standard and improved versions of the 'Acrid' will serve on through the early 1990 before being phased out.

Specification

AA-6 'Acrid'

Dimensions: IR version 5.80 m (19 ft 0.35 in) and SARH version 6.29 m (20 ft 7.64 ft); span 2.25 m (7 ft 4.58 in); body diameter 0.40 m (1 ft 3.75 in)

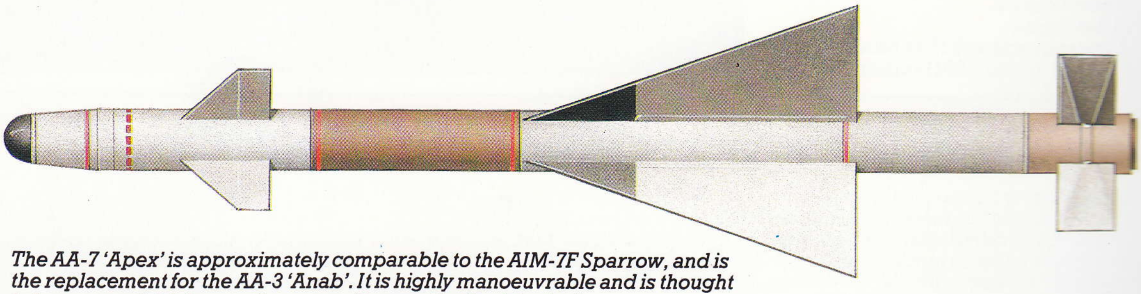
Launch weight: IR version 750 kg (1653.4 lb) and SARH version 800 kg (1763.7 lb)

Performance: speed Mach 4.5; range IR version 25 km (15.53 miles) and SARH version 70 km (43.5 miles)

Warhead: 90-kg (198.4-lb) HE blast fragmentation with contact and proximity fuses

USSR

AA-7 'Apex'



The AA-7 'Apex' is approximately comparable to the AIM-7F Sparrow, and is the replacement for the AA-3 'Anab'. It is highly manoeuvrable and is thought to have a much higher performance than earlier Soviet missiles.

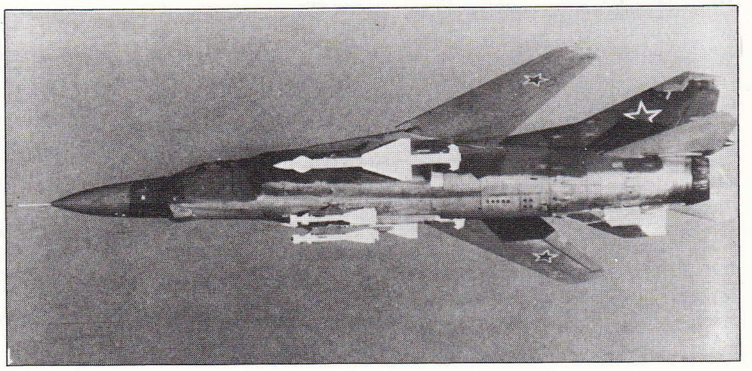
The solid-propellant low- to medium-altitude **AA-7 'Apex'** was first revealed in the late 1970s as a third-generation Soviet equivalent to the medium-range AIM-7 Sparrow missile that had been compromised during the Vietnam War. Since then American intelligence reports have identified two versions, the **AA-7a** and **AA-7b** that correspond to the IR (Soviet designation **R-23I**) and SARH versions respectively. Instead of the more standard single SARH seeker head, the AA-76 (Soviet designation **R-23R**) has four fin-like blade receiver antennae just aft of the nose that work on the interferometer principle. Flight control is achieved by a set of control fins at the tail around the rocket motor exhaust pipe, four much larger fixed delta wings being located approximately half way along the missile body itself.

The normal launch platform for the 'Apex' is the Mikoyan-Gurevich MiG-23 'Flogger' family with two missiles (one of each type) on the underwing glove hardpoints. The radar associated with the Soviet air force 'Flogger-B/G' versions is the limited look-down search-and-track J-band 'High Lark' set, which illuminates the target for missile-guidance purposes when it is in a continuous-wave mode. Apart from technology from the American Sparrow, the 'Apex' probably contains components from the 1950s developed AA-5 'Ash' IR and SARH missile family.

AA-7 'Apex' (continued)

The 'Ash' still equips the long-range Tupolev Tu-28 'Fiddler' interceptor. What is clear from analysis of Soviet air-to-air missile systems, however, is that they are very often developed for specific aircraft types rather than to the normal Western philosophy of developing a missile for a role and then fitting it to every suitable launch platform available. Current operators of the AA-7 are Czechoslovakia, East Germany, India, Libya, Syria and the USSR.

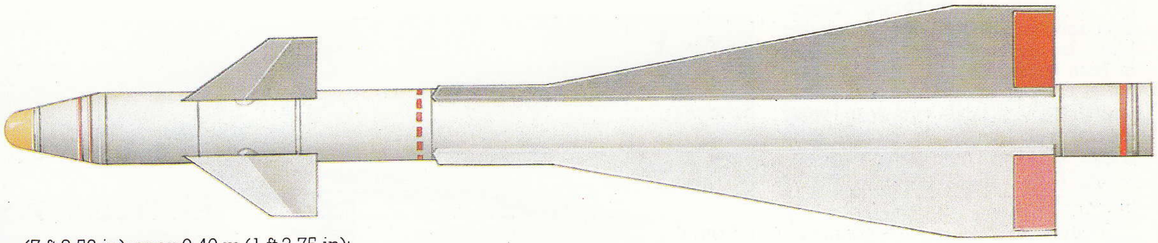
Specification
AA-7 'Apex'
Dimensions: length IR versions 4.20 m (13 ft 9.35 in) and SARH version 4.60 m (15 ft 1.1 in); span 1.40 m (4 ft 7.12 in); body diameter 0.223 m (8.78 in)
Launch weight: IR version 300 kg (661 lb) and SARH version 320 kg (705.5 lb)
Performance: speed Mach 3.5; range IR version 20 km (12.5 miles) and SARH version 55 km (34.2 miles)
Warhead: 40-kg (88-lb) HE fragmentation with contact and proximity fuses



A Soviet MiG-23 'Flogger-B' all-weather interceptor carries AA-7 'Apex' radar-homing missiles on its outer weapons pylons.

USSR

AA-8 'Aphid'



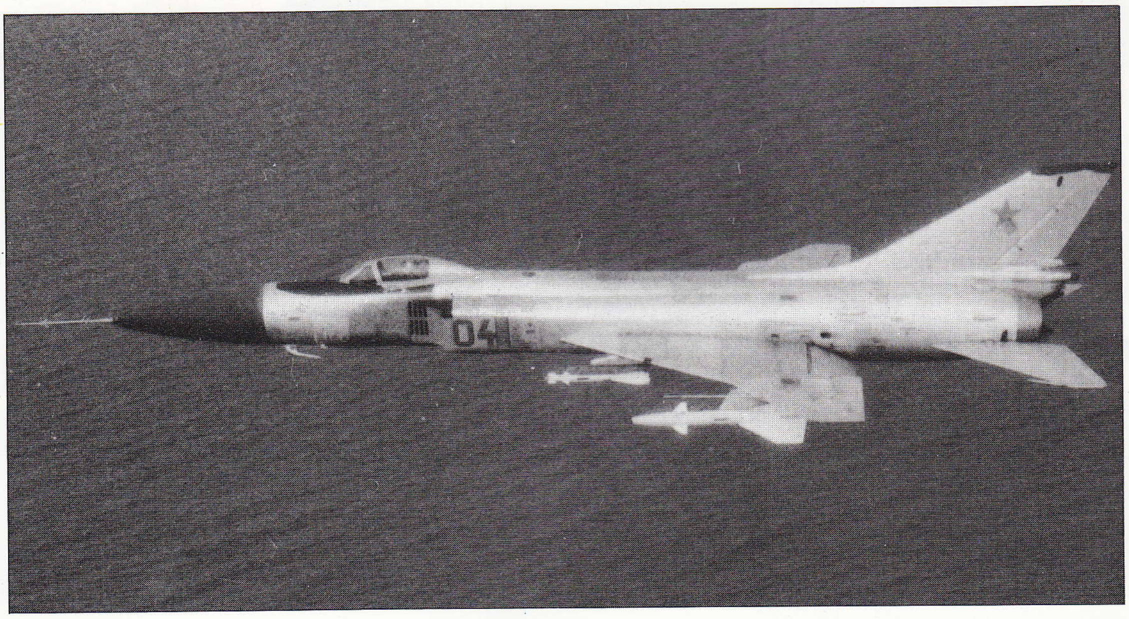
Above: The AA-8 'Aphid' is a small, close-combat air-to-air missile, probably designed to replace the AA-2 'Atoll'. It is said to be available in IR and SARH versions, but only the IR version has so far been seen in the West. Reports indicate that the AA-8 has already seen action in the Middle East, carried by Syrian MiG-23s.

The eventual replacement for the 'Atoll', the short-range **AA-8 'Aphid'** (Soviet designation **R60**) was revealed concurrently with the AA-7 'Apex' in the mid-1970s. Although only photographs of an IR-guided version have been released so far, there are persistent reports of a SARH version for use on the 'High Lark' radar-equipped Mikoyan-Gurevich MiG-23 'Flogger' and late-generation MiG-21 'Fishbed' interceptors. The AA-8 is one of the smallest guided air-to-air missiles yet built and is known to be carried on the MiG-23 (two or four missiles on underfuselage racks, plus two AA-7s), second- and third-generation MiG-21 (usually two IR-guided AA-8s with 'Advanced Atoll' SARH missiles on the outer pylons). Sukhoi Su-15 'Flagon' (two IR on underfuselage pylons, plus two AA-7s) and the Soviet navy's Yakovlev Yak-36MP, 'Forger-A' (usually two IR type on outer wing pylons). Apart from the USSR, AA-8 operators are Cuba, Czechoslovakia, East Germany, India, Libya and Syria. Reports from the Middle East indicate that Syria has already used the AA-8 as a dogfight missile in the air battles against Israel during the 1982 invasion of Lebanon with negligible results to date.

Designed specifically for the dogfight role, the AA-8 is a highly manoeuvrable missile with four delta wings at the tail and four canard delta control surfaces, the latter immediately aft of four nose-mounted fixed aerodynamic surfaces that may both aid in the guidance phase (by being an ECCM system) and enhance manoeuvring capbilities.

Specification
AA-8 'Aphid'
Dimensions: length IR version 2.15 m (7 ft 0.65 in) and SARH version 2.35 m (7 ft 8.52 in); span 0.40 m (1 ft 3.75 in); body diameter 0.12 m (4.72 in)
Launch weight: IR version 55 kg (121.25 lb) and SARH version 60 kg (132.3 lb)
Performance: speed Mach 3.0; range IR version 10 km (6.2 miles) and SARH version 15 km (9.23 miles)
Warhead: 6-kg (13.2-lb) HE blast fragmentation with contact and proximity fuses

Below: A Soviet Sukhoi Su-15 'Flagon' carries AA-3 'Anab' radar-homing missiles on its outer weapon stations, and a pair of AA-8 'Aphid' IR-homing dogfight missiles on its inner pylons. The aircraft was photographed over the Baltic Sea by Swedish air force fighters.



USSR

New-generation air-to-air missiles

According to leaked American intelligence reports there are at least three Soviet fourth-generation air-to-air missile systems that have just or are about to enter service with the Soviet air force.

The **AA-9** is an all-altitude all-aspects medium-range missile with snap-down capabilities for use against cruise missile targets. Possibly derived from AA-7 technology, the AA-9 appears to be the Soviet answer to the American AIM-7M Sparrow and British Sky Flash systems. It is carried by the Mach 2.4 Mikoyan-Gurevich MiG-31 'Foxhound' on four underwing pylons, and relies on the pulse-Doppler radar of the 'Foxhound' for target data. In trials it demonstrated the ability to intercept 'cruise missile' target drones flying at around 90 m (295 ft) whilst the launch platform flew at vertical separations in excess of 6000 m (19,685 ft). Claimed maximum ranges are 70 km (43.5 miles) at high altitude and around 40 km (24.85 miles) at low altitudes.

The **AA-X-10** is in its final development phase, and the missile is due to enter service in late 1984 with the MiG-29 'Fulcrum' and Sukhoi Su-27 'Flanker' interceptors. The AA-X-10 is a medium-range all-altitude missile, with terminal homing of the active radar type and capable of snap-down attacks. A high-altitude beyond-visual-range engagement capability in excess of 35-40 km (21.75-24.85 miles) is claimed, together with a low-altitude performance range of 12.5-20 km (7.5-12.4 miles)

The **AA-X-12(?)** is a new IR-guided dogfight missile which is stated to be comparable in performance with the American AIM-9L Sidewinder. It is expected to enter service in the mid- to late 1980s to arm the new generation of Soviet interceptors, the 'Fulcrum' and 'Flanker', as their standard dogfight missile.

US Navy

Part 2

USS Mississippi, the third 'Virginia' class cruiser, was designed as a highly capable carrier escort. Each of the twin missile launchers is capable of firing a variety of missiles, both surface-to-air and ASW.

Despite her size, a carrier carries only a point-defence and close-in armament, relying on her aircraft and escorts for deep-field defence. Ideally she will have an inner ring of four cruisers and an outer ring of possibly 10 destroyers, the former geared to anti-aircraft warfare and the latter to a mix of anti-aircraft and anti-submarine warfare.

Today's cruisers are 'double-enders', in that they have an area-defence SAM system fore and aft and, to reduce the dangers of a co-ordinated saturation attack, one of each group should be AEGIS-equipped. This system was designed to identify and track large numbers (reportedly 200) of aerial targets simultaneously.

The AEGIS-equipped ship can process its information near-instantaneously to identify friend from foe, assess each threat and, via the Naval Tactical Data System (NTDS) control and allocate the fire-power of the group's defences while controlling friendly aircraft.

Today's first-rate cruisers are developed from the nuclear-powered *Bainbridge* and her steam-powered sisters of the 'Leahy' class. To accommodate a second SAM system, these 5,700-tonners virtually dispensed with ASW armament but, stretched by only about 16 m (52.5 ft), the same basic layout has developed, via the 'Californias' to the 'Virginia' (CGN 38) class. These, at about 11,000 full load tons, have an excellent balanced armament though, even with two Standard MR launchers, they could still handle probably no more than four targets at a time. Construction was, therefore, halted at four in favour of a new AEGIS cruiser (the CGN 42 class) for the late 1980s. The extra complication of the electronics will, to some extent, be offset by the adoption of a vertical launch system (VLS) in place of dual-function launchers. Dependent upon mission, this arrangement will house SSMs, SAMs and ASMs stacked vertically below the upper deck in what resembles a milk crate in layout.

In the outer defence ring are ships of lesser capability, ideally destroyers, but, as a result of present lack of numbers, often fast frigates. Typically, the former are older ships like the 'Coontz' and 'Adams' class ships for anti-aircraft warfare and the new 'Spruance' class ships for anti-submarine warfare. The last can carry two LAMPS III (Light Airborne Multi-Purpose System Mk III) Sikorsky SH-60B Seahawk helicopters. Such aircraft are able to deploy both ASW sensors and weapons, besides having a measure of onboard data-processing capability to supplement the data-link with the mother ship. They can act also for identification of targets and mid-course correction duties to realize the full over-the-horizon range of the ship's Harpoon SSMs.

A new departure would be the carrying of air-to-surface missiles (ASMs) for use against minor combat vessels although, at the moment, European fleets seem to be ahead in this application.

The USS *Arleigh Burke* (DDG 51) is currently building as lead ship for another extensive destroyer series to replace older classes in sequence. They will feature both VLS and a simplified AEGIS and will in effect be a less expensive substitute for the current AEGIS vehicle, the 'Ticonderoga' (CG 47) class, of which about 20 are planned. These enormously expensive double-enders are built onto a 'Spruance' hull and machinery, and are categorized as cruisers on grounds of capability rather than size.

In addition to the 80-km (50-mile) Harpoon, larger escorts will be acquiring the Tomahawk cruise missile after the mid-1980s. Assuming that targeting is no problem, these will offer, effectively, another layer on the defence onion.

Layered defence

The principle of layered defence for a task group is a vital part of its overall philosophy, for the Soviets constantly exercise co-ordinated saturation attacks, using a variety of platforms such as long-range aircraft, surface ships and submarines. These can loose missiles to follow high and low trajectories over a wide choice of ranges, possibly the most dangerous being the missiles from SSGNs, which could follow up with torpedoes for good measure. Each must be annihilated, for nuclear heads can be fitted to all larger Soviet anti-ship weapons and a single 'leaker' could spell disaster.

A Standard MR medium-range air defence missile leaves the forward Mk 26 launcher of a 'Virginia' class cruiser. The latest versions of the Standard missile have greatly enhanced range and much more sophisticated electronics.

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Airborne early warning (AEW) from the carrier should enable the combat air patrol (CAP) to intercept an enemy air strike at extreme ranges before it can launch its ASM. Similarly, airborne radar should detect enemy surface forces before they can target the task group, laying the hostile ships open to counterattack by Tomahawks at up to 250 km (155 miles). Widely spread air strikes will, however, be beyond the capacity of the CAP and will come into the ambit of AEGIS. Standard ERs will be loosed by the outer screen at 50 km (31 miles); the threat of these being nuclear-tipped will keep the attacking aircraft well separated. Survivors crossing the outer line will be taken under attack by its point-defence missiles at about the same time that they come into the range of the medium-ranged weapons of the inner ring. Point-defence systems, which can tackle crossing targets, are carried by both the inner defences and the carrier herself. A current weakness in the American inventory is the lack of an effective low-level anti-missile missile, of the calibre of the British Seawolf. The standard weapon is the Sea Sparrow, but this needs replacement because of its slow reaction times and lack of low-level performance. As a result, the last-ditch defences would rely heavily on close-in weapon systems (CIWS) which, currently, is the Vulcan Phalanx. This Gatling-type gun can loose about 400 rounds in two short bursts in the time that the average transsonic SSM is within its range. Critics of the system point out that even with high-density penetrators the 20-mm rounds lack killing power against a hardened missile and that, with elevation limited to 85°, the terminal-diving SSM could evade it.

There remains, of course, the unseen defence of electronic countermeasures (ECM) and decoys, which can be highly effective in seducing a missile away from its chosen target. Unfortunately, with virtually every ship in the task group employing all means at its disposal, it is highly likely that SSMs will simply switch targets. No exercise can properly predict the likely outcome of a well co-ordinated attack against a well-armed and alert task group but, almost certainly, the day will be decided, one way or the other, in a matter of minutes.

USS* Elliott*, a 'Spruance' class destroyer, makes a high-speed turn. These large destroyers, the most numerous US destroyer programme since the war, are primarily ASW ships.

Lighter forces

Lacking the 'glamour' necessary to attract funding in competition with larger projects, the frigate, as understood in Western European terms, hardly existed in the US Navy before the early 1960s. By then, most surviving World War II destroyer escorts were totally obsolete.

The pair of 'Bronstein' class prototypes introduced the slim, high-freeboard hull and the ASROC stand-off anti-submarine missile, matched for range by the enormous bow-mounted sonar, a combination that proved successful enough to influence all succeeding classes. Anti-submarine potency was improved in the following 'Garcia' class by including an organic helicopter, though half the group ('Brooke' class) were completed with an area-defence SAM system.

A rather contentious feature, single-screw propulsion, has been retained (despite the fact that it lacks redundancy and fine manoeuvring control) through the following 46-strong 'Knox' class into the current 'Oliver Hazard Perry' programme, of similar numbers. In the latter class, shortcomings are offset to some extent by the incorporation of a pair of retractable azimuthal thrusters. Because of the versatility of the pair of embarked LAMPS III helicopters, the 'Oliver Hazard Perry' class ships have been able to discard ASROC and embark a dual-function launcher with a 40-round magazine capable of handling both the 16-km (10-mile) Standard MR SAM or the 80-km (50-mile) Harpoon SSM. This improvement in all-round capability is bought at the expense of complexity, any fault in the system thus robbing the ship of two major weapons. A further drawback is that their potential sees the ships sometimes elevated to the outer screen of a task group, a role for which they were never designed. Versatility is always gained at a price, however, and the 'Oliver Hazard Perry' class frigates are vulnerable to air attack pressed home to short ranges. They are scheduled to receive CIWS but lack any point-defence system, relying on the single 76-mm (3-in) gun amidships, a weapon too small to be of use for bombardment or anti-ship functions yet too slow to be credible against aerial targets.

USS* Lockwood*, one of 46 'Knox' class frigates operated by the US Navy, launches a Harpoon anti-ship missile from the dual-purpose octuple Harpoon/ASROC launcher. Criticized by some for their single-screw propulsion, the 'Knox' class forms the backbone of US frigate strength.